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WATERFOWL PRODUCTION ON ARTIFICIAL ISLANDS IN MOUNTAIN MEADOWS RESERVOIR, CALIFORNIA[1]

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In 1976 the California Department of Fish and Game constructed eleven nesting islands along the northern shoreline of Mountain Meadows Reservoir in northern California. We studied waterfowl nesting on these islands from March through July 1986 to determine waterfowl production and identify factors influencing productivity. Nests were located and nesting chronology was followed until the fate of all located nests and eggs was determined. Thirty-eight Canada goose, *Branta canadensis moffitti*, nests were located. Only 5% hatched successfully; 82% were destroyed by predation. Hatching success of eggs in successful nests was 40%. Forty-three duck nests were located. Of these nests, 40% hatched successfully and 44% were destroyed by predation. Hatching success of eggs in successful nests was 87%. Predation losses were primarily due to canids. Predation losses were greatest when reservoir elevations dropped, allowing canids to reach the islands. This study suggests that a combination of distance between islands and shore of approximately 60 to 150 m and water depths of 0.6 to 1 m are required to reduce canid predation at Mountain Meadows Reservoir.

INTRODUCTION

The construction of waterfowl nesting islands is a proven waterfowl habitat improvement technique. Islands provide small areas of nesting substrate which offer relative security from mammalian predators (Hammond and Mann 1956, Vermeer 1970, Ewaschuk and Boag 1972, Johnson, Woodward, and Kirsch 1978). Hammond and Mann (1956) and Giroux (1981) describe the characteristics which make islands attractive to nesting waterfowl, and provide recommendations for nesting island construction. Waterfowl species occurrence and abundance, existing levels of mammalian predation, vegetation cover conditions on the surrounding shoreline, and proximity of food and brooding habitat tend to determine if islands will attract nesting waterfowl. Important factors to consider in artificial nesting island construction are island location, spacing, maintenance, surrounding water depth, distance between the island and the shoreline, and water level fluctuation.

In 1976, Lassen County and the California Department of Fish and Game (CDFG) received California Duck Stamp funds for the construction of artificial nesting islands at Mountain Meadows Reservoir. That same year CDFG constructed eleven nesting islands in a cove along the northern shoreline of the reservoir.

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In 1986 we evaluated waterfowl nesting on the eleven islands to determine waterfowl production and identify factors influencing productivity.

STUDY AREA

Mountain Meadows Reservoir is located in Lassen County, California near the town of Westwood. The reservoir is about 1510 m in elevation. Average annual precipitation in the area is 97.5 cm and includes 34 cm of snowfall. Mountain Meadows Reservoir was created in 1924 by damming Goodrich Creek and Mountain Meadows Creek. Ninety percent of its 2,630 surface ha are less than 3 m deep at maximum water surface elevation, and 70% of the reservoir is less than 1.8 m deep at maximum water surface elevation. The primary use of the reservoir is for hydroelectric power generation. Livestock grazing is a secondary use of the Mountain Meadows Reservoir property.

The reservoir is bordered by approximately 2,000 ha of marsh and meadow. The marshes are dominated by sedges, *Carex* sp., and wire rush, *Juncus balticus,* with lesser amounts of cattail, *Typha* sp., and white water buttercup, *Ranunculus aquatilus.* The meadows support various native and introduced grasses and herbs. Open to dense stands of conifers, dominated by ponderosa pine, *Pinus ponderosa,* and lodgepole pine, *Pinus murrayana,* surround the reservoir and wetlands.

Common reed, *Phragmites communis,* is the dominant vegetation cover on the majority of the eleven islands. Dense patches of thistle, *Cirsium* sp., are present on several of the islands. Wire rush, *Verbascum* sp., and *Phacelia* sp. are present in lesser amounts.

Mountain Meadows Reservoir provides valuable waterfowl habitat for a variety of species. It is recognized as a major waterfowl production area in California (California Department of Fish and Game 1983), and provides nesting habitat for the ring-necked duck, *Aythya collaris,* lesser scaup, *Aythya affinis,* (Hunt and Anderson 1966), wood duck, *Aix sponsa,* bufflehead, *Bucephala albeola,* mallard, *Anas platyrhynchos,* cinnamon teal, *Anas cyanoptera,* redhead, *Aythya americana,* and Great Basin Canada goose, *Branta canadensis moffitti.* It also provides wintering habitat for many other species.

The eleven nesting islands are located in a cove along the northern shoreline of Mountain Meadows Reservoir. The islands were designed to have an exposed area of about 9 m $\times$ 3 m at maximum water surface elevation (1511.4 m) and an apical portion about 1 m above the maximum water surface. Water surface elevations ranged from 1510.0 to 1511.1 m during the study period of 1 March through 25 July 1986. The exposed area of each island during this period was at least twice the design size.

METHODS

Waterfowl nesting activity was monitored from 20 March through 25 July 1986. The nesting islands were systematically searched by two people on foot to locate waterfowl nest sites. Nests were assigned a number and mapped using landmarks on the island as reference points. To reduce attraction of avian predators no markers were placed at nest sites (Hammond and Forward 1956, Dwernychuk and Boag 1972, Picozzi 1975). Mapping proved satisfactory for relocating the nests on subsequent visits.

Each nest and island was surveyed every 5–13 days depending on weather and nesting chronology until the fate of all located nests and eggs had been determined. A hatching date was estimated for each clutch based on the initial location date, egg laying rates, and incubation period (Bellrose 1978). Each nest was examined on or near the estimated hatching date. No effort was made to separate initial nesting from renesting attempts. The categories used to classify the fate of nests were derived from Miller and Collins (1953) and included:

(i) Hatched (some or all of the eggs had live hatched, and the completed nest contained shell fragments and membranes resulting from hatched eggs);

(ii) Destroyed by predation (the nest showed evidence of disturbance by a predator, such as the presence of shell fragments in and about the nest, or the presence of destroyed eggs or scattered down);

(iii) Flooded (the surrounding water level had risen above the level of the nest, or the nest site was close enough to the water level that wave action was sufficient to wash over the nest, and the wave action either destroyed the nest entirely, or led to subsequent abandonment);

(iv) Abandoned (egg laying or incubation had ceased and no evidence of predation, flooding or other disturbance was present);

(v) Other losses (the nest showed evidence of disturbance by something other than a natural predator or flooding, such as trampling by livestock, or egg removal by humans, or the nest or eggs were missing and no evidence of hatching was present).

Information presented by Dow (1943) and Rearden (1951) aided in identifying nest predators. If any eggs remained in a nest beyond a reasonable incubation period for that species and/or incubation activity at the nest had ceased, the eggs were removed and examined for fertility. Egg fertility was based on the criteria described by Kossack (1950).

RESULTS AND DISCUSSION

Canada Geese

Nesting Chronology

Canada goose nests were first located on 20 March. The most advanced nest contained seven eggs and was estimated to have been initiated between 3–8 March. The peak of egg laying occurred between 29 March and 11 April. All nesting activity had ceased by 10 June.

Nesting Success

Thirty-eight Canada goose nests were located during the 1986 nesting season (Table 1). Fifteen of the nests exhibited evidence of disturbance that occurred prior to their initial discovery. In addition, five inactive nest depressions were located during the study period (these were not included in calculations of production or nest success). Of the nests located, 82% were destroyed by predation, 5% hatched, 8% were abandoned, and 5% succumbed to other losses.

TABLE 1. Summary of Waterfowl Nesting Success During the 1986 Nesting Season at Mountain Meadows Reservoir.

Species	*Total nests*	*Nests hatched*	*Predation*				*Abandoned*	*Other losses*
			Canid	*Bird*	*Unknown*	*Total*		
Canada goose	38	2	19	2	10	31	3	2 *
Mallard	36	14	8	8	1	17	2	3 +
Cinnamon teal	6	2	2	0	0	2	2	0
Redhead	1	1	0	0	0	0	0	0
Total ducks	43	17	10	8	1	19	4	3

* One nest lost to human disturbance, fate of one nest undetermined.

+ Two nests lost to cattle trampling, fate of one nest undetermined.

Dow (1943), Miller and Collins (1953), Naylor (1953), and Naylor and Hunt (1954) reported predation losses on island, wetland, and upland habitat in northeastern California of 2.5% to 26.6%. Giroux (1981) found 17% of Canada goose nests on islands in southeastern Alberta, Canada were subject to predation. Of the 31 nests lost to predation at Mountain Meadows Reservoir, 61% were destroyed by canids (coyote, *Canis latrans,* and domestic dog), 6% by birds (probably common raven, *Corvus corax,* black-billed magpie, *Pica pica,* and gulls, *Larus* spp.), and 32% by unidentified predators. Goose nesting begins prior to spring runoff when water levels are low, allowing canid predators access to the nesting islands (Figure 1).

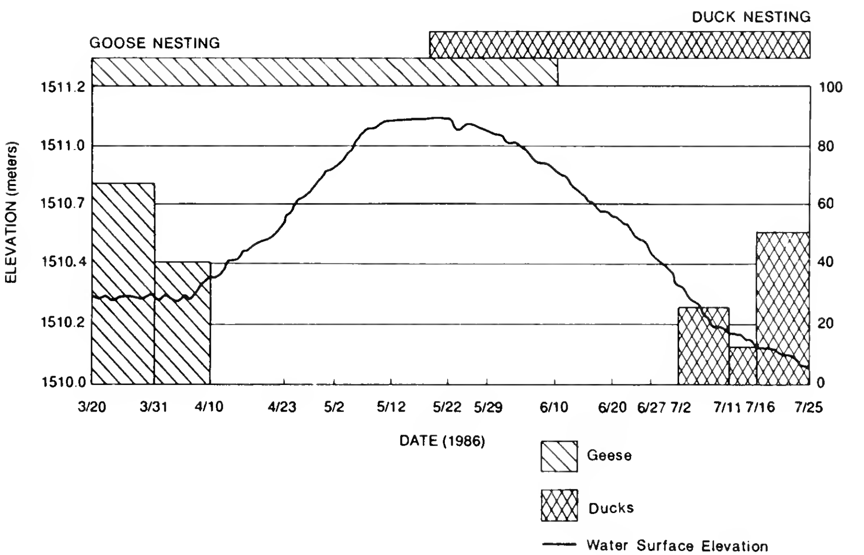

FIGURE 1. Water surface elevation and waterfowl nest predation by canids at Mountain Meadows Reservoir (1986).

The percentage of nests that hatched successfully (5%) was substantially lower than the 52.5% to 79.3% reported by Dow (1943), Naylor (1953), and Naylor and Hunt (1954) in the Honey Lake Valley, and Miller and Collins (1953) at Tule Lake and Lower Klamath National Wildlife Refuges. The

percentage of nests that were abandoned (8%) is within the range reported by Dow (1943), Miller and Collins (1953), Naylor (1953), and Naylor and Hunt (1954) of 6.5% to 23.9%.

Crowded nesting conditions have been reported to cause stress and an increase in nest abandonment by Canada geese (Miller and Collins 1953, Naylor 1953). Multiple nesting occurred on nine of the 11 islands at Mountain Meadows Reservoir with 3 m being the shortest distance between nests and 45 m the farthest. Nesting densities on the islands ranged from a low of 9 nests/ha to a high of 125 nests/ha. At the highest nesting density, on a 0.04 ha island, two of five nests (40%) were abandoned.

Hatching Success

The two nests in which at least one egg hatched contained 10 eggs for an average clutch size of five. Forty percent of the eggs hatched, 50% were fertile but did not hatch and one egg was destroyed by an unknown cause (Table 2).

TABLE 2. Summary of Waterfowl Hatching Success During the 1986 Nesting Season at Mountain Meadows Reservoir.

Species	*Total eggs*	*Eggs hatched*	*Infertile*	*Dead embryos*	*Canid predation*	*Other losses*
Canada goose	10	4	0	5	0	1
Mallard	135	123	0	4	8	0
Cinnamon teal	20	19	1 *	0	0	0
Redhead	10	1	0	0	8	1
Total ducks	165	143	1	4	16	1

* Egg laid in mallard nest.

The average clutch size observed in this study is comparable to that reported by Naylor and Hunt (1954) in the Honey Lake Valley (5.1 on Honey Lake Refuge and 5.3 on the Susan River), and Miller and Collins (1953) at Tule Lake and Lower Klamath National Wildlife Refuges (5.13). However, the observed hatching success (40%) was considerably lower than that reported by either Naylor and Hunt (1954), who observed hatching successes of 64.9% (Honey Lake Refuge) and 79.3% (Susan River), or Miller and Collins (1953) who observed a hatching success of 87%. Geis (1956) and McCabe (1979) cited below freezing temperatures during the laying period as having a probable influence on poor hatching success by chilling the eggs. It is possible that low temperatures also influenced the observed hatching success at Mountain Meadows Reservoir. High winds and freezing temperatures occurred during the period the nests were initiated. The influence of weather on the hatching success of Canada goose eggs may have been increased by harassment of the laying and incubating adults by canid predators. Such disturbance could increase the time that eggs were left unattended and the time they were exposed to the effects of high winds and low temperatures.

Nesting Sites

Vegetation cover on the islands provided very little concealment when the Canada geese began nesting. Goose nesting began before the vegetation had started its spring growth, and residual vegetation was minimal due to cattle grazing. The majority of goose nests (60%) were located in common reed. Rock, a hollow log, and bare ground (24%), willow, *Salix* sp. (13%), and wire

rush (3%) also provided nest sites. With the exception of the hollow log, in which only one nest was located, these cover types did not appear to differ in the degree of concealment they provided for Canada goose nests.

The majority of goose nests were highly visible, and provided an unrestricted view for the nesting geese. Hammond and Mann (1956) reported that vegetation cover is usually of minor importance in selection of preferred nesting sites by geese. Steel, Dalke, and Bizeau (1957) stated that the cover type is of minimal importance as long as the basic requirements for nesting sites are met. The basic requirements are listed by Williams and Sooter (1940) as: (i) presence of substantial nest bases; (ii) nearness to open water; (iii) good visibility; (iv) accessible brood-rearing areas; (v) accessible grazing areas; and (vi) available aquatic feeding and loafing areas. The islands at Mountain Meadows Reservoir met all of these requirements, except the presence of substantial nest bases. The nest bases available on the islands consisted of the rock and soil substrates of the islands and remnants of 55 gallon drum ends and tires placed on the islands during construction in 1976. Drum ends and tires were used as nest sites, but more often nests were located elsewhere on the islands even when these bases were available.

Ducks

Nesting Chronology

The first duck nest located was a mallard nest estimated to have been initiated 20–21 May. The first cinnamon teal nest was estimated to have been initiated 29 May–1 June. The only other species that nested on the islands was a redhead and its nest was estimated to have been initiated on 10–11 June. The peak of egg laying for ducks occurred between 7 June and 20 June. All nesting activity had ceased by 25 July. The nesting season of 20 May through 25 July began and ended somewhat later than that reported by Hunt and Anderson (1966) for Mountain Meadows Reservoir. This was probably due to a severe winter which delayed suitable nesting conditions.

Nesting Success

Forty-three duck nests were located during the 1986 nesting season (Table 1). Of the nests located, 44% were destroyed by predation, 40% hatched, 9% were abandoned, and 7% succumbed to other losses. Hunt and Naylor (1955), Miller and Collins (1954), and Rienecker and Anderson (1960) reported predation losses on island, wetland, and upland habitat in northeastern California of 3.5% to 35.0%. Giroux (1981) found 14.5% of duck nests on islands in southeastern Alberta, Canada were subject to predation. Of the 19 nests lost to predation at Mountain Meadows Reservoir, 53% were destroyed by canids, 42% by avian predators, and one by an unidentified predator. Although duck nesting begins during periods of high water levels in the reservoir, water is drawn from the reservoir for hydroelectric generation during the nesting season. This allows canid predators to access the islands during the latter portion of the duck nesting period (Figure 1).

The percentage of nests that hatched successfully (40%) was lower than the 50.1% to 84.8% reported by Hunt and Naylor (1955) in the Honey Lake Valley, and Miller and Collins (1954) and Rienecker and Anderson (1960) at Tule Lake

and Lower Klamath National Wildlife Refuges. The percentage of duck nests that were abandoned (9%) is comparable to the range reported by Miller and Collins (1954), Hunt and Naylor (1955), and Rienecker and Anderson (1960) of 7.8%–14.2%. One parasitized mallard nest which contained eight mallard eggs and one cinnamon teal egg was observed. The mallard hen incubated the nest and hatched seven of the mallard eggs. The cinnamon teal egg was later examined and found to be infertile.

Hatching Success

Of the duck nests in which at least one egg hatched, fourteen mallard nests produced 135 eggs for an average clutch size of 9.6; two cinnamon teal nests produced 19 eggs for an average clutch size of 9.5; and one redhead nest produced 10 eggs. Of the 165 eggs; 87% hatched, 2% were fertile but did not hatch, one was infertile, 10% were destroyed by canid predators, and one was lost to an unknown cause (Table 2). The clutch sizes and hatching success (87%) are comparable to those reported by Hunt and Naylor (1955) in the Honey Lake Valley, and Miller and Collins (1954), and Rienecker and Anderson (1960) at Tule Lake and Lower Klamath National Wildlife Refuges (clutch sizes of 8.4 to 10.5, and hatching success of 83.9% to 91.7%).

Nesting Sites

Considerably more vegetation cover was present on the islands when the ducks began nesting than when the Canada geese began nesting. When the peak of egg laying occurred (7 June through 20 June), dense cover of common reed (0.3–1.2 m in height) and thistle (0.3–1 m in height) occurred on the islands. The majority of duck nests (61%) were located in common reed. Thistle (37% of nest sites) and wire rush (2% of nest sites) also provided nesting cover. Most duck nests were well concealed. Miller and Collins (1954) and Hammond and Mann (1956) reported a preference by nesting ducks for dense broadleaved herbaceous cover such as nettle or thistle, over grasses. This study did not evaluate nesting site cover preference.

CONCLUSION

Giroux (1981) concluded that, "Construction of islands may enhance productivity of wetlands for waterfowl in areas where nesting cover is a limiting factor. The technique is promising and should be used more extensively on the breeding grounds of North America". Mountain Meadows Reservoir is an important waterfowl production area in California (California Department of Fish and Game 1983) and limited cover, the result of livestock grazing, and heavy predation have reduced the capability of the area to produce waterfowl. The construction of nesting islands in 1976 was an effort to increase productivity of this important area.

The nesting success of Canada geese and ducks using the islands at Mountain Meadows Reservoir was extremely low during the 1986 nesting season. The occurrence of multiple Canada goose nests on nine of the 11 nesting islands and multiple duck nests on 10 of the 11 nesting islands indicates that the islands were attractive as waterfowl nest sites. However, a low percentage of nests hatched successfully due primarily to a high incidence of predation, principally by canids. Canids are able to access the islands early in the goose nesting season

prior to spring runoff, when reservoir elevations are low, and late in the duck nesting season, when the reservoir is drawn down by hydroelectric generation and evaporation. Water stored in Mountain Meadows Reservoir is subject to extensive evaporation due to the large surface area: depth ratio of the reservoir. Because the water is used for hydroelectric power generation it is discharged as early in the year as possible, to minimize evaporative losses.

Hammond and Mann (1956) recommended that nesting islands be separated from the mainland by at least several hundred feet of open water from 1.0–1.5 feet (0.30–0.46 m) deep in order to keep the islands predator free. Based on relationships between the nesting success of ducks and the distance from islands to the mainland, Giroux (1981) recommended that nesting islands be separated from the mainland by a distance of at least 170 m of open water approximately 0.7 m deep. This study indicates that at Mountain Meadows Reservoir, a minimum water elevation of 1510.4 m is effective in reducing waterfowl nest losses to canid predators (Figure 1). Consequently, a combination of distance between islands and shore of approximately 60–150 m and water depths of 0.6–1.0 m are required to reduce canid predation losses.

We examined water elevation data from Mountain Meadows Reservoir for the period 1977 through 1985 to determine how often waterfowl nests on the islands were susceptible to canid predation. We assumed that nests were only susceptible to canid predation when water elevations were less than 1510.4 m (see Figure 1), and that goose and duck nesting periods were similar to those we observed in 1986. Based on these assumptions, Canada goose nests were susceptible during the entire nine year period, and duck nests were susceptible during five of those nine years.

Techniques recommended to increase waterfowl nesting success on the islands at Mountain Meadows Reservoir include: (i) placing elevated nesting structures on the islands; (ii) relocating the islands to areas of the reservoir which provide deeper water throughout the nesting period; and (iii) increasing the water depth during the nesting season at the existing islands by creating a moat.

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ENTERIC SEPTICEMIA OF CHANNEL CATFISH IN CALIFORNIA [1]

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Cultured channel catfish, *Ictalurus punctatus,* at Imperial Valley Warmwater Hatchery in southeastern California were found to be infected by *Edwardsiella ictaluri,* the bacterium which causes enteric septicemia of catfish. The bacterium was identified by standard biochemical and serological methods, and produced disease signs and pathology consistent with those observed elsewhere in the United States. A severe outbreak of the disease occurred in fingerling catfish, but mortality was eventually controlled using feed supplemented with oxytetracycline and vitamins. This was the first reported occurrence of enteric septicemia of catfish in California and although surviving fingerling catfish seemed to be free of infection, they were later destroyed to prevent spread of the disease. No infected wild catfish were found in the hatchery water supply, leaving the source of the outbreak uncertain.

INTRODUCTION

Enteric septicemia of catfish (ESC) is a major cause of mortality in farm-reared channel catfish, *Ictalurus punctatus,* in the southeastern United States (Wellborn et al. 1985). The disease is caused by the enteric bacterium, *Edwardsiella ictaluri* (Hawke 1979), which attacks the brain, liver, spleen and kidney (Miyazaki and Plumb 1985). The disease usually occurs at water temperatures between 22°C and 28°C (Plumb 1984). *E. ictaluri* has also been isolated from white catfish, *Ictalurus catus,* brown bullhead, *Ictalurus nebulosus* (Plumb and Sanchez 1983), green knife fish, *Eigemannia virescens* (Kent and Lyons 1982), danios, *Danio devario* (Waltman et al. 1984), and walking catfish, *Clarias batrachus* (Kasornchandra et al. 1987).

Since channel catfish are reared extensively by public and private hatcheries in California, fishery managers and private fish farmers are concerned about the potential spread of catfish diseases into California. In the spring of 1987, we began a study to determine if ESC was present within California. This report describes the isolation of *E. ictaluri* and observation of an outbreak of ESC at a public catfish hatchery.

METHODS

Laboratory

We examined channel catfish for the presence of *E. ictaluri* by blood culture and by inoculating agar plates from internal organs. All forms of bacteriological media used were incubated at 25°C. Blood cultures were made by aspirating

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approximately 3–5 ml of blood from the heart directly into individual blood culture tubes (Becton-Dickenson) containing 50 ml of thioglycollate broth with sodium polyanethulesulfonate. After two d of incubation, 0.1 ml from each tube displaying turbidity was spotted and streaked onto a 5% sheep blood agar (BA) plate to obtain isolated bacterial colonies. Internal organs of catfish were exposed using sterile instruments and procedures. The brain, liver and kidney were stabbed with sterile loops and the material streaked onto BA plates. Plates from either blood cultures or internal organs were examined after 48 h for the presence of small smooth round white oxidase-negative colonies made up of gram-negative short rods. Such colonies were restreaked on BA and then inoculated into triple sugar iron (TSI) and citrate agar slants, and into indole and malonate broths, in order to determine the biochemical characteristics of the bacterial isolates.

The original typestrain of *E. ictaluri* (Hawke 1979) was obtained from the American Type Culture Collection (ATCC), Bethesda, MD. This typestrain, ATCC #33202 and an isolate of *Edwardsiella tarda,* a related bacteria commonly infecting catfish (Plumb 1984), were also inoculated into the biochemical test media to verify the accuracy of our materials and procedures. Rabbit antisera were made against ATCC #33202 and *E. tarda.* Bacterial isolates suspected to be *E. ictaluri* were confirmed by a slide agglutination test against undiluted antisera to *E. ictaluri* and *E. tarda.*

In addition to culture methods, the presence of bacteria in the organs of fish with clinical ESC was shown by Gram stain of tissue smears and Leishman-Giemsa staining of touch preparations (Amos 1985). Organs for histopathological examination were fixed in Bouin's solution, processed and sectioned by routine methods, and stained with hematoxylin and eosin. Examination of fish for the presence of channel catfish virus was according to Amos (1985).

Field Sampling

On 8 June 1987, during a routine fish disease inspection of the State of California Imperial Valley Warmwater Hatchery (IVWH), 25 yearling channel catfish (wt = 545–1,135 g) were collected by angling from a one acre pond, which had a surface water temperature of 29°C. These apparently healthy fish were sampled by blood culture.

On 20 June 1987, in response to a request by IVWH personnel to assess abnormal fish behavior, three moribund fingerling channel catfish were collected from a five-acre pond (Hatchery Pond Number Two), which had a surface water temperature of 34°C. Kidney and brain material from the three fish were streaked onto blood agar. Microscopic examination of kidney, liver and spleen tissue sections and smears were made. Portions of these three organs were also submitted for virological testing.

Following diagnosis of ESC, all fish at IVWH were treated with feed supplemented with one g of oxytetracycline per 363.2 g feed (2,500 g per ton), administered at 3% of body weight/day, beginning on 20 June. On 1 July, dead and moribund channel catfish from another five-acre pond (Hatchery Pond Number Six) were sampled for ESC. On 3 July, all ponds at IVWH received one g of oxytetracycline per 182 g feed, with double the normal vitamin supplement. This therapy was continued for 42 d.

A quarantine was placed on IVWH on 1 July; no fish were being planted then and no fish were planted thereafter. In early August, the five-acre ponds were drained and fish inventoried. The severity of the mortality was estimated by comparing the percentage survival in Pond Numbers Two and Six with the percentage survival in the unaffected ponds.

To evaluate the efficacy of the oral oxytetracycline therapy, 60 fish from Hatchery Pond Number Two (the pond which had the highest fish mortality) were randomly selected 58 d after the drug treatment ended. Brain, liver and kidney material were inoculated onto blood agar. Water temperature ranged from 23–29°C in this pond during the 21 d period prior to sampling.

IVWH and private catfish hatcheries in Imperial County use Colorado River water through an extensive canal system, which contains channel catfish, yellow bullhead, *I. natalis,* and flathead catfish, *Pylodictus olivaris.* If ESC is present in wild catfish in the canal system, future catfish production in the Imperial Valley will be at risk to disease outbreaks. The Niland extension of the Highline Canal, which delivers water to IVWH, was sampled in October 1987 to determine if *E. ictaluri* could be found in wild catfish. The water temperature was 23°C. Material from the brains and kidneys of 43 channel catfish and 17 yellow bullhead was streaked onto blood agar plates. Twenty channel catfish were gill-netted from a 3-acre reservoir at the hatchery which stores unfiltered, untreated canal water prior to use in the ponds; the water temperature was 22°C at time of sampling. An additional 32 channel catfish were sampled from the same reservoir in January 1988; the water temperature was 15°C. Approximately 350 channel catfish were removed from the reservoir as it was drained.

RESULTS

From the catfish blood cultures sampled on 8 June at IVWH, colonies resembling those of *E. ictaluri* were subcultured. The organism was gram negative, rod shaped, slightly motile, produced gas from glucose and was indole, citrate and malonate negative. On TSI slants, the organism produced an alkaline slant and an acid butt with gas, but no hydrogen sulfide. These biochemical reactions constitute a presumptive identification for *E. ictaluri* (Plumb 1984).

The three catfish sampled on 20 June were bloated, and hemorrhages were seen at the base of the pectoral fins, on the lower edge of the operculum and internally on the mesentery. These disease signs are consistent with previous descriptions of infections by *E. ictaluri* (Hawke 1979; Plumb 1984). No virus was detected in the kidney, liver and spleen material from these three fish. Gram-negative rods were abundant in kidney smears and sparsely present in brain tissue smears from all three fish. Rod-shaped bacteria were abundant in kidney macrophages stained with Leishman-Giemsa (Figure 1). Replication or aggregation of *E. ictaluri* within phagocytic cells has been previously observed (Miyazaki and Plumb 1985). Microscopic tissue examination revealed extensive necrosis of hematopoietic areas of the hind kidney, as well as degeneration of glomerular and tubular elements (Figure 2). Focal areas of hepatic cell and pancreatic cell necrosis were found in the liver (Figure 3). Infection by *E. ictaluri* causes kidney and liver necrosis (Areechon and Plumb 1983). Kidney and brain blood agar streaks produced bacteria with biochemical characteristics typical of *E. ictaluri.* Bacterial isolates from yearling and fingerling catfish were

agglutinated by rabbit *E. ictaluri* antiserum from Auburn University, and by rabbit antiserum we produced against the type strain ATCC 33202 (Hawke et al. 1981). No agglutination was observed when these isolates were mixed with antiserum to *E. tarda.* Dr. J. A. Plumb, Department of Fisheries and Allied Aquaculture, Auburn University, confirmed the isolate from fingerling channel catfish as *E. ictaluri* by biochemical and serological tests.

In spite of the oxytetracycline treatment, the disease spread to at least one other 5-acre hatchery pond, possibly due to transfer of infected fish by bird predators. Infected fish exhibited spiraling behavior or motionless hanging at the pond surface, as described by Hawke (1979). Isolations of *E. ictaluri* were made from dead and moribund fish from pond Number Six on 1 July. Following increased drug and vitamin therapy, losses had essentially ceased by 9 July, 22 d after the outbreak of the disease. However, mortality from ESC often recurs after discontinuing medicated food (Plumb and Quinlan 1986). Hence, extended drug therapy was used at IVWH to prevent recurring mortality and spread of ESC to other ponds. No *E. ictaluri* were found in the 60 fish sampled from Hatchery Pond Number Two following drug therapy.

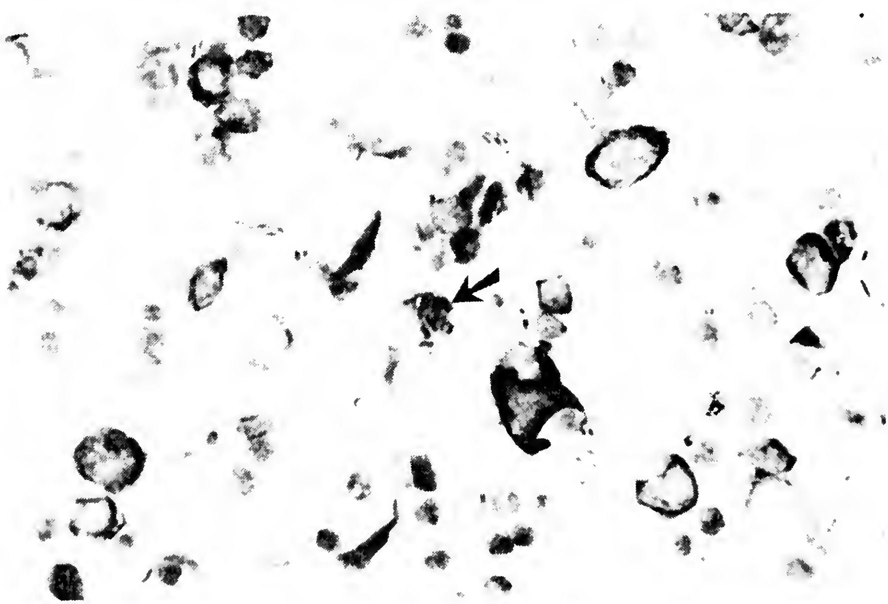

FIGURE 1. Leishman-Giemsa stained impression smear from infected channel catfish kidney at 1000X. Rod-shaped bacteria appear singly or within vacuoles of macrophages (arrow).

FIGURE 2. Kidney of channel catfish infected with *Edwardsiella ictaluri.* Paraffin section stained with H & E at 200X. Kidney displaying necrosis of hematopoietic tissue (n), hemorrhage (h) and tubular degeneration (arrow).

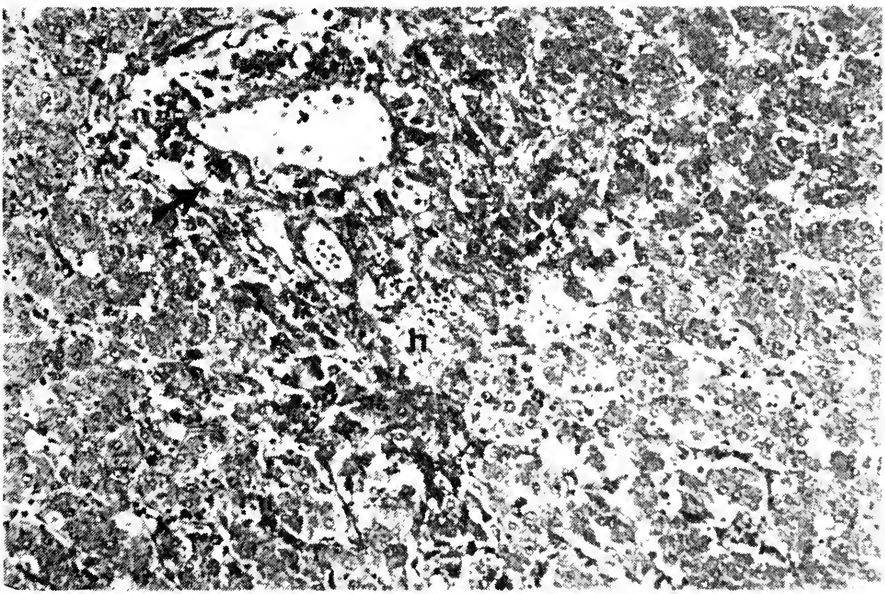

FIGURE 3. Paraffin section of infected channel catfish liver, stained with H & E at 200X. Liver shows focal necrosis of hepatic cells (h) and necrosis of pancreatic cells lining a bile duct (arrow).

The loss caused by the disease was estimated by the hatchery manager at 130,000 fish, or 12.3% of the initial number of fry seeded. Since this outbreak of disease at IVWH was the first known occurrence of ESC in California, the California Department of Fish and Game attempted to stop its spread by not planting any fish from the 1987 brood year. The decision was made before the data on the efficacy of the drug therapy were available. The remaining 850,000 fish were buried, except for 500 retained for 1989 egg production. Likewise, 500 18-month-old broodfish were destroyed and 250 were saved for 1988 egg production. Fish saved for future egg production received an intraperitoneal injection of 1 mg oxytetracycline per 18 g (25 mg/lb) prior to introduction into previously dried earthen hatchery ponds. Currently, only eggs disinfected with iodophor may be brought into the hatchery production facilities; broodfish present during the 1987 outbreak will be destroyed after egg collection. Production ponds at IVWH were drained, treated with 1,000 lb/acre $Ca(OH)_2$ disked to a depth of six inches, and allowed to remain dry for six months prior to being refilled for 1988 BY fish rearing. Although *E. ictaluri* can survive in wet mud for up to 95 days (Plumb and Quinlan 1986), the chemical treatment plus the widely varying temperatures, arid climate, and intense solar radiation in the Imperial Valley should have facilitated disinfection.

No. *E. ictaluri* were found in the brains and kidneys of wild catfish sampled from the Niland extension of the Highline Canal nor in the brains, liver or kidneys of fish sampled from the reservoir at IVWH.

DISCUSSION

This report describes the first outbreak of ESC in channel catfish in California. A severe mortality was observed in at least two hatchery ponds before it was controlled by medication. If the surviving fish had not been destroyed, the estimated 130,000 fish loss would not have affected the hatchery's annual production goal of 500,000 catchable-sized fish. However, if the other ponds had been as heavily affected as ponds Two and Six, production goals would have been threatened. Experience at IVWH and in the southeastern United States indicated that although ESC outbreaks can cause severe mortality and raise production costs, they can be controlled by early diagnosis and proper drug therapy (Plumb and Quinlan 1986).

We did not observe the "hole in the head" lesion (ulceration of the skull) often produced by *E. ictaluri* (Hawke 1979). The "hole in the head" condition is not always present in catfish infected with *E. ictaluri* (Moore et al. 1984). Infection appears to occur by two routes: (i) via the nares, leading to a chronic brain infection and systemic infection; and (ii) via the gut, causing rapid septicemia usually without brain involvement (Shotts et al. 1986). The number of moribund fish examined by us during the outbreak of ESC at IVWH was not sufficient to support either route of infection; however, the bacteria was easily cultured from both brains and kidneys.

ESC can recur in the fall following a spring outbreak (Miyazaki and Plumb 1985), possibly due to bacteria surviving in pond bottom muds (Plumb and Quinlan 1986), reintroduction of the bacterium when fingerlings are stocked into a partially harvested pond, or from latent infections. The disease did not recur at IVWH after chemotherapy ended, possibly because of the extended

period of drug treatment or because fish were raised in discrete production lots without restocking. The number of fish sampled after oxytetracycline therapy, and the number of wild fish sampled in the canal and 3-acre reservoir was sufficient to provide 95% confidence of finding *E. ictaluri* once in populations with a 5% incidence of infection (Amos 1985). However, the incidence of fish carrying *E. ictaluri* may be lower than 5%. Therefore, the failure to isolate *E. ictaluri* from drug-treated and wild fish did not prove that it was completely absent from these populations. Although the disease outbreak was effectively controlled by chemotherapy, the California Department of Fish and Game chose to destroy the fish to minimize any possibility of spreading ESC. Further sampling of commercial catfish farms and wild or feral catfish populations is in progress to determine if *E. ictaluri* is widespread within California.

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RECORDS OF RARE EELPOUTS OF THE GENUS *LYCODAPUS* GILBERT IN THE NORTH AND SOUTHEASTERN PACIFIC OCEAN, WITH AN ADDITION TO THE CALIFORNIA MARINE FISH FAUNA[1]

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New records of the rare deep-sea eelpout genus *Lycodapus* are reported, considerably extending the ranges of five of the 13 species. These include *L. psarostomatus* from Monterey Bay, California, *L. microchir* from the Ryukyu Islands, Japan, *L. endemoscotus* from the Bering Sea and off Peru, and *L. dermatinus* and *L. fierasfer*, also from off Peru.

INTRODUCTION

The eelpout genus *Lycodapus* Gilbert is one of the most distinctive genera in the family Zoarcidae in its morphological adaptations to deep-sea life. Anderson (1984) enumerated five unique diagnostic characters for *Lycodapus* among eelpouts: (i) gill slit free of isthmus posteriorly; (ii) suborbital pores absent; (iii) only one (lacrimal) suborbital bone present; (iv) first preopercular pore and dentary foramen absent; and (v) three branchiostegal rays articulating with ceratohyal and three with epihyal. *Lycodapus* (13 species) and *Melanostigma* (seven species) are the only known meso- or bathypelagic zoarcid genera, having species occupying these realms well off the bottom or associated with it for spawning or feeding (Belman and Gordan 1979, Markle and Wenner 1979, Anderson 1981, 1984, Silverberg et al. 1987). In addition to the five characters listed above, *Lycodapus* is further diagnosed by its lack of pelvic fins and scales, cartilaginous pectoral actinosts, small pectoral fins with only 5–9 rays, few (13–19) precaudal vertebrae, gelatinous flesh, lack of an oral valve, and the mandibular and preopercular canals separated by a septum. The species of *Lycodapus* were reviewed by Peden and Anderson (1978, 1981) and were then known from the waters of Japan across the North Pacific rim to the Gulf of Panama, in cold-temperate South America, and the Scotia Sea. A disjunction in distribution between the northern hemisphere species and three southern hemisphere forms occurred at Panama, with no records of *Lycodapus* along the entire coast of western South America (Peden and Anderson 1978, 1981, Anderson 1988). This report documents three of the northern species off Peru.

Since the reviews mentioned above, additional noteworthy specimens of *Lycodapus* were recently brought to my attention from oceanographic collections made by three countries. These are a specimen from Japanese waters collected by fisheries research investigations in the Okinawa Trough, the three Peruvian specimens collected by the Soviet Academy of Sciences, and five specimens from the Bering Sea and one from Monterey Bay, California,

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collected by the U. S. National Marine Fisheries Service (NMFS). These range extensions,some rather extreme, and identification criteria are discussed below. Important counts and measurements are also included.

METHODS AND MATERIALS

Methods of counting fin rays from x-radiographs follow Anderson (1982), not Peden and Anderson (1978), the difference being the latter authors added the epural caudal rays, usually two, to dorsal fin counts. Measurements are given in percent standard length (SL). Institutional abbreviations are as listed in Leviton et al. (1985), with emendations after Leviton and Gibbs (1988).

Lycodapus psarostomatus Peden and Anderson, 1981

(Figure 1)

A single specimen of the specklemouthed eelpout was collected in Monterey Bay, California, with a midwater trawl fished close to the surface at night by the NMFS Juvenile Rockfish Survey in 1986 and forwarded to the author for study. This collection represents a range extension southward along the slope from the Bering Sea of some 4700 km (Peden and Anderson 1981), and is here added as new to the California marine fish fauna. The specimen is identified on the basis of its peculiarly speckled mouth, low gill raker ratio (rakers mere nubs), high vertebral count, and gill slit extending only slightly above the pectoral fin base.

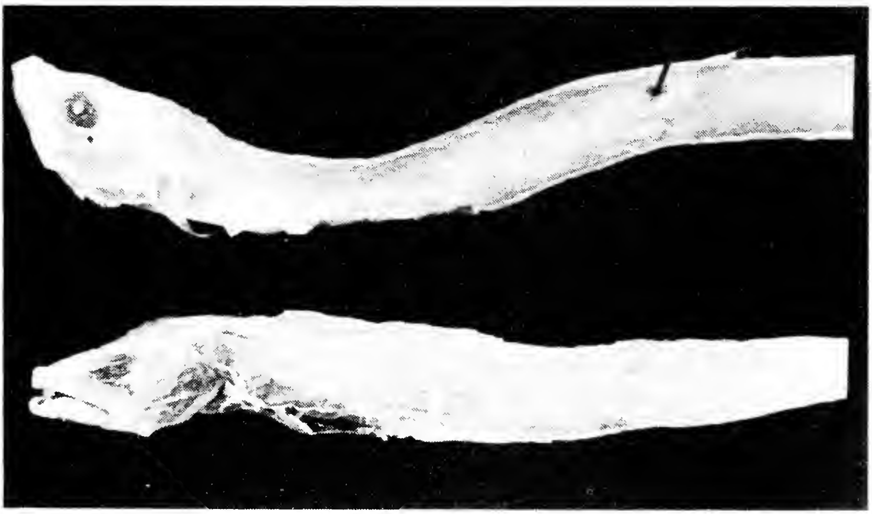

FIGURE 1. Anterior aspect of *Lycodapus psarostomatus* (above), CAS 58902, from Monterey Bay, and *L. microchir* (below), NSMT P-18957, from the Ryukyu Islands, Japan. Photo by author.

Selected counts and measurements as follows: vertebrae 20 + 84 = 104; D 98; A 86; C 2 + 5 + 4 = 11; P 8; gill rakers 0 + 10; vomerine teeth 9; palatine teeth 14/16; mandibular pores 4; preopercular pores 3; interorbital pore 1; predorsal length 17.2; preanal length 34.7; body depth 6.0; head length 13.4. Gill raker ratio 29%.

Material: CAS 58902 (female; 98 mm SL); Monterey Bay, California; lat 36°35.0'N, long 122°02.2'W; R/V DAVID STARR JORDAN sta. 109; midwater trawl, 0–15m; 0028–0100 hr; 23 June 1986.

Lycodapus microchir Shmidt, 1950

(Figure 1)

A specimen of this rare eelpout was collected off the central Ryukyu Islands, Japan, with a bottom trawl in 1973 and discovered by the author at the National Science Museum in Tokyo. This collection represents a range extension southward from the Okhotsk Sea of some 1850 km (Peden and Anderson 1981). However, Peden and Anderson (1981: 677) reported a damaged specimen (USNM 148787) from west of Kyushu Island, Japan, they did not positively identify. Based on that specimen's vertebral count (16 + 63 = 79), gill raker shape and ratio (50%), vomerine and palatine tooth counts, and locality, it can only be identified as *L. microchir*, despite the low pectoral ray counts (6/7 vs. 8) and obscured pores. The newly discovered Ryukyu Island specimen is identified on the basis of its size and maturity, low gill raker ratio, and low vertebral count, despite the unusual number of preoperculomandibular pores (6 vs. 8).

Selected counts and measurements as follows: vertebrae 14 + 62 = 76; D 69; A 61; C 2 + 4 + 4 = 10; P7; vomerine teeth 6; palatine teeth 11/13; mandibular pores 3; preopercular pores 3; interorbital pore 1; predorsal length 23.3; preanal length 37.9; body depth 8.1; head length 20.0. Gill raker ratio 63%.

Material: NSMT P-18957 (male; 71 mm SL); W. of Amami Isl., Ryukyu Islands, Japan; lat 28°38.9'N, long 128°12.5'E; SOYO-MARU sta. 69; bottom trawl, 1130 m; T. Okutani, 2 Feb. 1973.

Remarks: Peden and Anderson (1981: 670–671) tentatively allied this species with their *L. endemoscotus* on similarities of pore pattern and short gill raker ratio.

However, *L. pachysoma* Peden and Anderson, 1978 is more similar to *L. microchir* on the basis of those same characters plus relatively few vertebrae (vertebrae 76–86 in *L. microchir* and 75–82 in *L. pachysoma* vs. 86–95 in *L. endemoscotus*). *Lycodapus microchir*, however, differs from *L. pachysoma* by its small adult size (mature at 70–80 mm SL; *L. pachysoma* matures at about 165–180 mm SL), smaller head and less robust body, and differentiated jaw teeth (like that of *L. dermatinus* or *L. fierasfer* vs. viliform in *L. pachysoma*; see Peden and Anderson 1978: figs. 9–10). Other material of *L. microchir* studied since Peden and Anderson (1981) in the collections of the Zoological Institute, Leningrad, USSR, and the Hokkaido University Faculty of Fisheries, Hakodate, Japan, require changes in their key couplet 4, since the vertebral range for *L. microchir* (above) overlaps that of *L. pachysoma* (couplet 4A). *Lycodapus microchir* is best distinguished from *L. pachysoma* by the characters given above, plus their ranges may not overlap. *Lycodapus microchir* is now known from the Ryuku Islands, Japan, as reported here, to the Shirshov Ridge, western Bering Sea; *L. pachysoma* is known from off western Canada to Oregon (at least), with a separate population in the subantarctic (Peden and Anderson 1978, Anderson 1988).

Lycodapus endemoscotus Peden and Anderson, 1978

(Figure 2)

Five specimens of this deep-water eelpout were captured in the south-central Bering Sea with an otter trawl by the NOAA vessel MILLER FREEMAN (NMFS survey) in 1983 and donated to the California Academy of Sciences by the collector, Jim Long. These two captures represent a range extension northward along the slope from British Columbia of some 3600 km (Peden and Anderson 1978). A single specimen of *L. endemoscotus* was collected off Peru with a beam trawl fished on the bottom by the Soviet Academy of Sciences vessel AKADEMIK KURCHATOV in 1968 and sent to the author for study by Dr. A. P. Andriashev of the Zoological Institute, Leningrad. This capture represents a range extension southward along the slope from the Gulf of California of some 6700 km (Peden and Anderson 1978; see also Parin and Makushok 1973: 175, 183). All six of these specimens are identified on the basis of their characteristic gill raker shape and ratio, vertebral counts, relatively large head, and preoperculomandibular pore patterns.

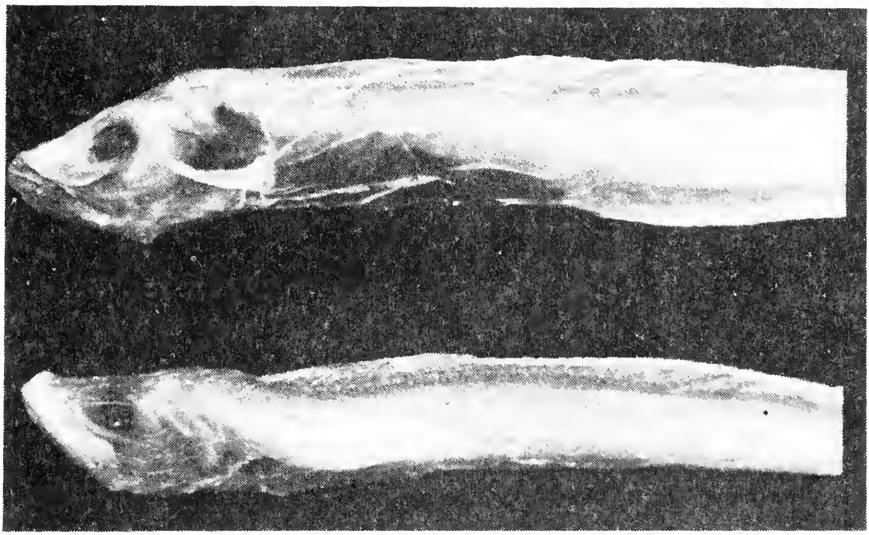

FIGURE 2. Anterior aspect of *Lycodapus endemoscotus* (above), CAS 55606, from the Bering Sea, and *L. dermatinus* (below), ZMMGU P-13657, from Peru. Photo by author.

Selected counts and measurements of the Bering Sea specimens as follows: vertebrae 16–17 + 69–73 = 86–89; D 79–85; A 70–72; C 1–2 + 3–4 = 8–9; P 6–8; gill rakers 0–1 + 9–10 = 9–11; vomerine teeth 8–13 (28 mm SL hatchling with 2); palatine teeth 10–16 (absent in 28 mm specimen); mandibular pores 3; preopercular pores 4; interorbital pore 1; predorsal length 19.6–21.7; preanal length 35.8–38.1; body depth 4.7–8.2; head length 17.7–22.1. Gill raker ratio 49–76%.

Selected counts and measurements of the Peruvian specimen as follows: vertebrae 17 + 77 = 94; D 88; A 78; C 2 + 4 + 4 = 10; P 8; gill rakers 1 + 10; teeth not counted; mandibular pores 4; preopercular pores 4; interorbital

pore 1; predorsal length 19.3; preanal length 37.3; body depth 7.9; head length 16.8. Gill raker ratio 84%.

Material: CAS 55605 (4; 28–109 mm SL); No. of Atka Island, Bering Sea; lat 52°15.9'N, long 174°51.5'W; R/V MILLER FREEMAN; 20 m otter trawl, 468–571 m; 8 Aug. 1983. CAS 55606 (male, 105 mm SL); W. of Great Sitkin Island, Bering Sea; lat 52°02.4'N, long 176°23.0'W; R/V MILLER FREEMAN; 20 m otter trawl, 439–512 m; 6 Aug. 1983. ZIN (uncat.; 1, 107 mm SL); off Trujillo, Peru; R/V AKADEMIK KURCHATOV, sta. 290, haul 216; Sigsbee beam trawl; 1830 m; 30 Oct. 1968.

Lycodapus dermatinus Gilbert, 1896

(Figure 2)

One specimen of *L. dermatinus* was collected off Peru with a bottom trawl by the Soviet Academy of Sciences' vessel PROFESOR MESYACHEV in 1972 and discovered by the author at the Zoological Museum of Moscow State University. This collection represents a range extension southward along the slope from the Gulf of California of some 7500 km (Peden and Anderson 1978). The specimen is identified on the basis of its long gill rakers, pectoral fin and vertebral counts (especially precaudal), and single interorbital pore.

Selected counts and measurements as follows: vertebrae 13 + 69 = 82; D 77; A 68; C 2 + 4 + 5 = 11; P 8; gill rakers 2 + 12; vomerine teeth 4; palatine teeth 2/2; mandibular pores 3; preopercular pores 3; interorbital pore 1; predorsal length 21.5; preanal length 33.5; body depth 8.1; head length 18.4. Gill raker ratio 194%.

Material: ZMMGU P-13657 (female, 88 mm SL); off Paracas Peninsula, Peru; lat 13°57'S, long 76°42'W; R/V PROFESOR MESYACHEV, cr. 1, sta. 104, trawl 44; 600 m; 7 Aug. 1972.

Lycodapus fierasfer Gilbert, 1890

One specimen of the blackmouth eelpout was collected off Peru in the same haul as the *L. endemoscotus* above (ZIN uncat.; Parin and Makushok 1973). This collection represents a range extension southward from off Malpelo Island of some 1500 km (Peden and Anderson 1978). The specimen is identified on the basis of its long gill rakers, head length; two interorbital pores, and preoperculomandibular pore pattern. The tip of the tail of this specimen was cut off making counts of the axial skeleton incomplete or impossible.

Selected counts and measurements as follows: vertebrae 15 + 73 (+); dorsal, anal, and caudal rays not determinable; P 7; gill rakers and teeth not counted; preopercular pores 3; mandibular pores 3; interorbital pores 2; predorsal length 20.2; preanal length 33.0; body depth 9.0; head length 19.5. Gill raker ratio 164%.

Material: ZIN uncat. (1; 125 mm SL); off Trujillo, Peru; lat 08°27'S, long 80°37'W; R/V AKADEMIK KURCHATOV sta. 290; Sigsbee trawl, 1830 m; 30 Oct. 1968.

DISCUSSION

The 13 species of *Lycodapus* form three distinct assemblages on the basis of gill raker shape and length (Peden and Anderson 1978, 1981). Other characters, although relatively few, were used to further distinguish the species. One of these, pore patterns of the preoperculomandibular canal, is now thought to be less informative than originally proposed for *Lycodapus*. Some variability in pore number, but not position, was noted in the other eelpout genera *Gymnelus* (Anderson 1982) and *Melanostigma* (Anderson 1988). The Japanese *L. microchir* (NSMT P-18957) adds another species to the list of those *Lycodapus* with variably three or four preopercular pores (others: *L. antarcticus, L. australis, L. dermatinus, L. endemoscotus,* and *L. parviceps*), or three or four mandibular pores (others: *L. australis, L. derjugini, L. dermatinus,* and *L. poecilus*) (Peden and Anderson 1981: table 2). Although most species generally maintain a particular pattern, geographical variation in pore pattern may exist in some species, as Peden (1979) found with vertebrae in *L. mandibularis.* Unfortunately, because of poor sample sizes, this is presently untestable, although it is interesting to note that the one species represented by thousands of specimens, *L. mandibularis,* showed no variation in its preoperculomandibular pore pattern (Peden and Anderson 1978). The important characters for identifying the species of *Lycodapus* remain gill raker shape and ratio, veterbral counts, dentition patterns, and, to a lesser extent, preoperculomandibular pore patterns, except for the unusual autapomorphies, e.g., gill opening in *L. parviceps* (Peden and Anderson 1978).

The Bering Sea specimens identified here as *L. endemoscotus* narrow the gap between *L. microchir* and that species (Peden and Anderson 1981). It may be that *L. endemoscotus* is an eastern Pacific population of *L. microchir,* in which case the species would range from tropical Japanese waters to Peru (at least), a not completely improbable distribution considering the range of *L pachysoma* (Peden and Anderson 1978; Anderson 1988). With the new material, *L. microchir* and *L. endemoscotus* are reliably distinguishable only on the basis of vertebral counts and geography if head pore patterns are ignored. This narrow splitting is also the situation with *L. derjugini* (western North Pacific) and *L. poecilus* (eastern Bering Sea; Peden and Anderson 1981), yet I prefer to recognize all differences at the specific level owing to the constancy of character expression among present samples.

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DUCK HARVEST ON PUBLIC HUNTING AREAS IN CALIFORNIA[1]

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We summarized hunter visits and success, and the magnitude and species composition of the duck harvest recorded on California public hunting areas (PHAs) during 1950–87. Hunter visits and harvest increased during 1950–74 as new PHAs were added, then declined concurrently with duck populations. Of six geographic regions, the Sacramento Valley, with numerous PHAs and the largest duck concentrations, accounted for the largest portion of PHA hunter visits (28%) and harvest (35%). Duck population levels, regulations, and hunter numbers affected PHA hunter success. Success was highest during 1955–59 but declined with no consistent trend after 1960. Species vulnerability, abundance, distribution, and hunter preference affected harvest composition. Northern pintails, *Anas acuta*, averaged 27% of the PHA harvest but declined in importance after 1974. Green-winged teal, *A. crecca*, the most important species in southern regions, averaged 21% of the PHA harvest. Mallards, *A. platyrhynchos*, averaged 16% of the PHA harvest but increased in importance after 1974 to become the most common duck bagged after 1983. PHA harvest comprised a small (4–16%) portion of the total state harvest. However, this portion increased from 1950–70 because of increased hunter visits to new PHAs and after 1970 because hunter success on PHAs did not decline as on other areas. PHA hunters tended to harvest fewer preferred species and more vulnerable species, as proportions of total bag, than did other hunters. The continued decline in numbers of waterfowl hunters presents important challenges for management of waterfowl areas in California.

INTRODUCTION

California wintering grounds are critically important to North American waterfowl populations. About 60% of Pacific Flyway and 18% of North American waterfowl winter in California (Gilmer et al. 1982). Recent midwinter duck counts have exceeded 5 million (Figure 1, Pacific Flyway Study Committee 1951–84, U.S. Fish and Wildlife Service, unpubl. data) and 10–12 million waterfowl winter in or pass through the state. Moreover, California is the primary wintering area for several duck species. About 75% of the northern

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pintails, *Anas acuta*, and 80% of the northern shovelers, *A. clypeata*, in the Pacific Flyway winter in California's Central Valley (U.S. Fish and Wildlife Service 1978).

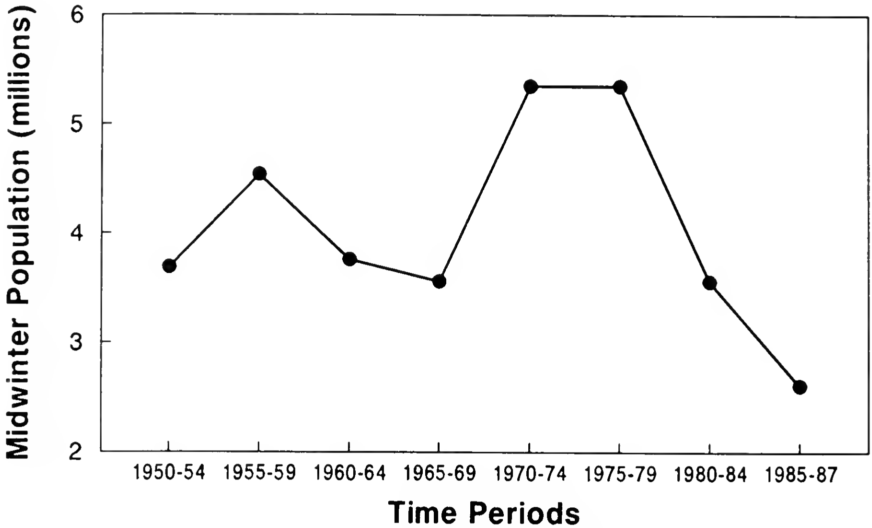


FIGURE 1. Average annual midwinter duck population in California by 5-year periods from 1950–87 (Pacific Flyway Study Committee 1951–84, U.S. Fish and Wildlife Service unpubl. data).

Before 1944, Klamath Basin National Wildlife Refuges (NWRs) in northeast California (Figure 2) were the only public lands in the state open to waterfowl hunting. In response to a heavy demand for waterfowl hunting opportunities and to preserve wetland habitats, an extensive public hunting area (PHA) network was subsequently established in California (Kozlik 1955). Currently, 20 state areas and 15 NWRs are open to waterfowl hunting in California.

Prime waterfowl hunting opportunities have enabled California hunters to harvest more ducks than do hunters in any other state, averaging 1.8 million ducks per year during 1971–80 (Carney et al. 1983). California duck hunting regulations (Figure 3, Bartonek et al. 1980) have been relatively stable and liberal compared to those in other flyways. Hunting seasons have ranged from a 44-day split season to a 95-day continuous season (average 83 days) and daily bag limits have varied from 5 to 7 ducks with restrictions some years on canvasbacks, *Aythya valisineria*, redheads, *A. americana*, wood ducks, *Aix sponsa*, and hooded mergansers, *Lophodytes cucullatus*. During 1952–58 and 1974, 2 to 4 additional northern pintails or American wigeon, *Anas americana*, were allowed. During 1985–87, only 1 female mallard, *A. platyrhynchos*, and 1 female northern pintail were permitted in the daily bag. Steel shot regulations were implemented in portions of Klamath Basin NWRs in 1984 and were gradually expanded to include the bulk of California PHAs by 1987.

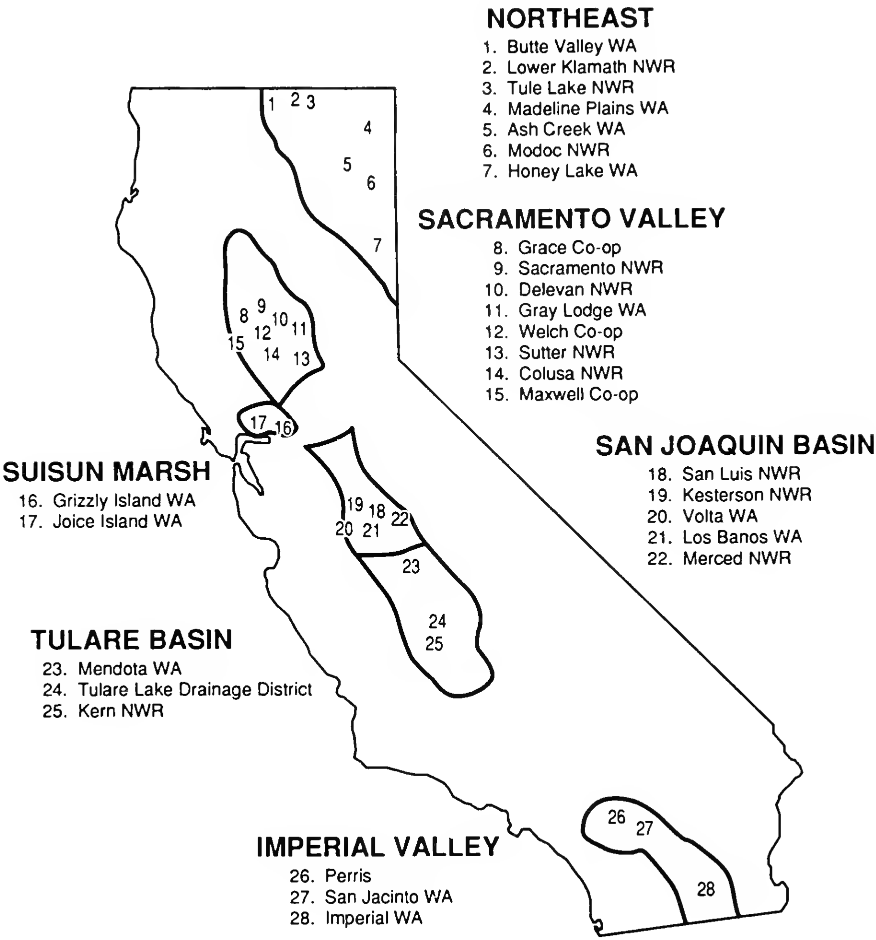


FIGURE 2. Location of geographic regions with public hunting areas in California.

In this paper we summarize species composition and regional differences in the duck harvest and trends in the participation and success of duck hunters on PHAs in California from records collected from 1950–87. These summaries will be useful to waterfowl managers as a historical record to predict future trends in species composition of the harvest on public areas and to compare harvest on public vs. that on private lands. Our information will provide a basis for obtaining better data at hunter check stations to meet changing requirements for population information and will assist in development of hunt programs on newly acquired areas. Most importantly, these summaries will focus attention on wetland habitat management specific to the species of interest including those that are declining and those that have increased in the harvest.

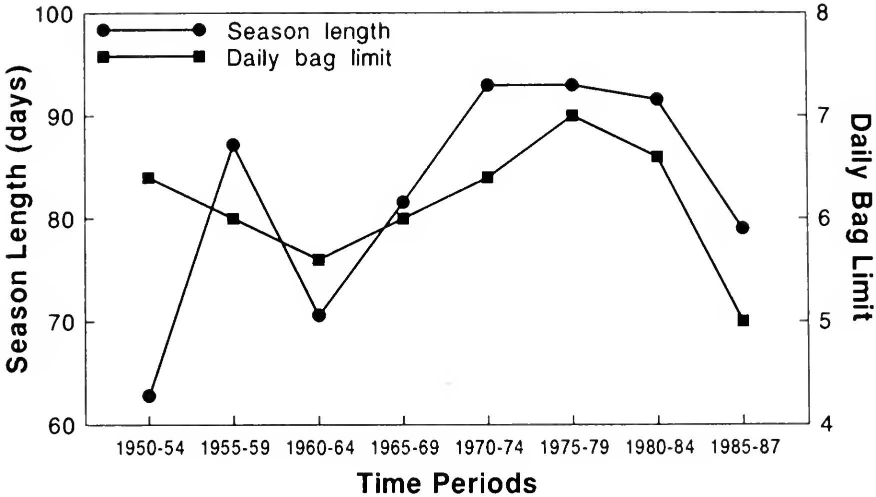


FIGURE 3. Average season lengths and daily bag limits for duck hunting in California by 5-year periods from 1950–87 (Bartonek et al. 1980).

METHODS

Harvest Areas

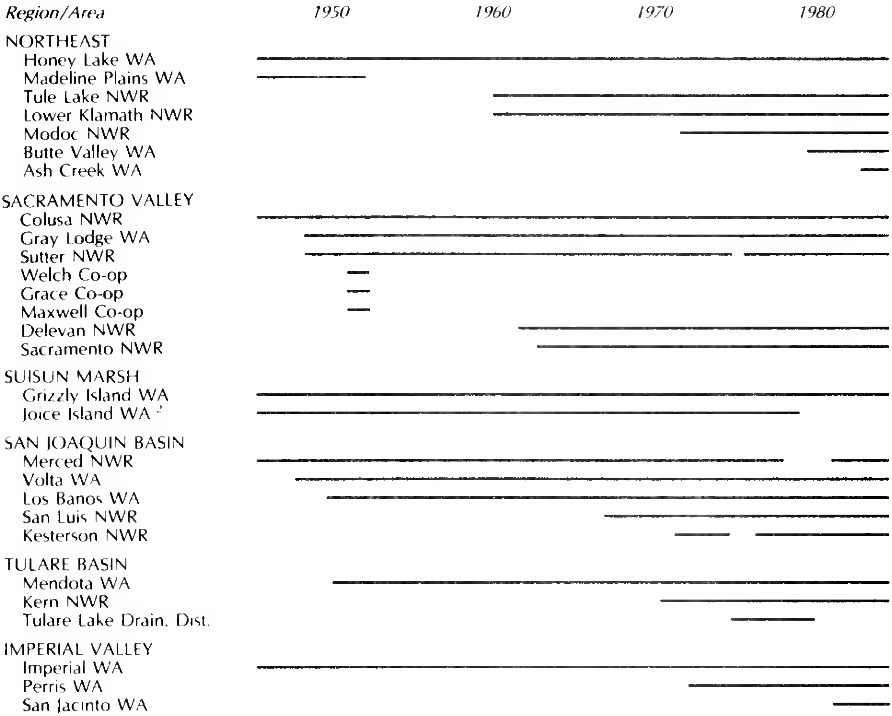
Waterfowl harvest data were obtained from the records of 28 PHAs on which managers operated check stations or conducted routine bag checks (Table 1, Figure 2). PHAs included NWRs, state Wildlife Areas (WAs), and cooperative areas (Co-ops) leased by the California Department of Fish and Game (CDFG). We grouped the areas into 6 geographic regions: Northeast, Sacramento Valley, Suisun Marsh, San Joaquin Basin, Tulare Basin, and Imperial Valley. Harvest data were not available for coastal public hunting areas.

Opportunities to hunt waterfowl on these areas fluctuated annually because: (i) WAs and NWRs were sometimes closed to hunting; (ii) tracts open to hunting within a specific hunting area varied; and (iii) potential hunting capacity varied because of changes in allowable hunting methods (e.g., blinds, free roaming) and flooded acreage.

Data Collection

Numbers and species of ducks killed and total numbers of hunter visits per year were obtained for each area. We define a hunter visit as 1 individual visting a PHA 1 day to hunt waterfowl. CDFG employees recorded these data at check stations on all areas except Tule Lake, Lower Klamath, and Modoc NWRs. U.S. Fish and Wildlife Service (USFWS) employees conducted bag checks of about 80% of the hunters (10% before 1975) on Tule Lake and Lower Klamath NWRs (E. H. McCollum, pers. comm.) and of about 50% of the hunters on Modoc NWR (E. C. Bloom, pers. comm.). Total car counts and average number of hunters per car were made on these NWRs to derive an estimated total daily harvest of each species.

TABLE 1. Years Duck Harvest Data were Collected from Individual Public Hunting Areas in California, 1950–87 [1].



[1] Hunting programs were in operation on Honey Lake, Madeline Plains, and Imperial WAs and Klamath Basin NWRs before 1950 (Kozlik 1955, Gilmer et al. 1986).

[2] Combined with Grizzly Island in 1983.

We summed daily harvest of each species and total hunter visits for the entire season for each PHA. For certain summaries we pooled harvest data for each region into 5-year time periods (3 years for most recent period). Data were analyzed separately for northern pintail, mallard, American wigeon, northern shoveler, green-winged teal, *Anas crecca,* other dabbling ducks (including gadwall, *A. stepera,* cinnamon teal, *A. cyanoptera,* blue-winged teal, *A. discors,* wood duck, fulvous whistling duck, *Dendrocygna bicolor,* and unknown dabblers), and diving ducks (including canvasbacks, redheads, ring-necked ducks, *Aythya collaris,* scaup, *Aythya* spp., goldeneyes, *Bucephala* spp., bufflehead, *B. albeola,* ruddy ducks, *Oxyura jamaicensis,* scoters, *Melanitta* spp., mergansers, *Mergus* spp., and unknown divers).

RESULTS

Statewide Harvest on PHAs

Average annual hunter visits to California PHAs and average annual duck harvest peaked during 1970–74 and declined thereafter (Figure 4). The greatest number of hunter visits (166,646)occurred during 1970 (1970–71 hunting season) and the largest annual harvest (299,230 ducks) occurred during 1974.

Hunter success peaked during 1955–59 (Figure 4) with the greatest success (2.9 ducks per visit) in 1956. After 1960, success was lower but no consistent trend occurred. Annual success after 1960 ranged from 1.1 ducks per hunter visit in 1977 (second year of a 2 year drought in California) to 2.1 ducks per visit in 1967. Northern pintails accounted for 27% of the harvest overall but declined in importance after the 1950s (Figure 5). For example, northern pintails composed 39% of the average annual harvest during 1950–54 but only 18% by 1985–87. Green-winged teal accounted for 20% of the harvest overall and increased in importance after the 1950s. Mallards accounted for 16% of the harvest overall, increased in importance in the 1980s, and became the most common duck harvested after 1983. Other species important in the harvest were northern shovelers (13%) and American wigeon (12%). No other species exceeded 5% of the harvest overall.

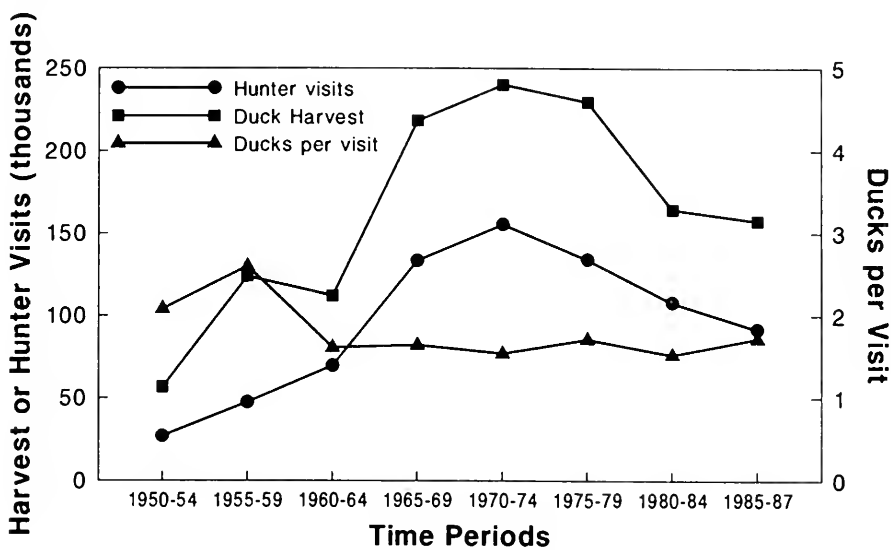


FIGURE 4. Average number of hunter visits, ducks harvested and hunter success (ducks per visit) on public hunting areas in California by 5-year periods from 1950–87.

Regional Harvest

Northeast—About 21% of the total harvest on PHAs occurred in the Northeast. Tule Lake and Lower Klamath NWRs accounted for most (86%, 1962–87) of the Northeast duck harvest. Data for these refuges were available only after 1962 (Table 1), thus explaining the marked increase in hunter visits and total harvest during 1960–69 (Figure 6). Hunter visits, which composed 27% of the total, and harvest declined in the region after 1974. Conversely, hunter success gradually increased after the early 1960s and by 1985–87 success was similar to 1955–59 peak values. Mallards and northern pintails were the primary species harvested (Figure 7), comprising >60% of the average total harvest for all periods. The apparent inverse relationship between these two species was more pronounced than in other regions in California. American wigeon gradually increased in importance in the harvest after 1955–59.

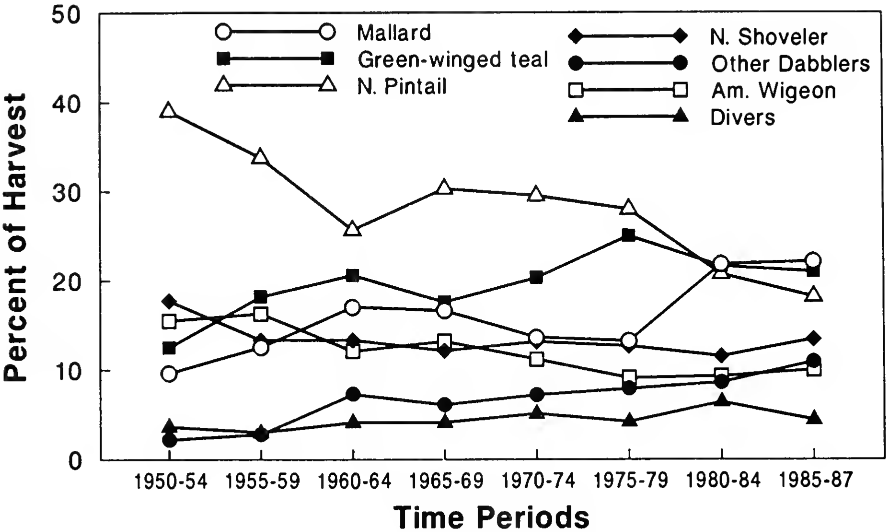


FIGURE 5. Average species composition of the duck harvest on public hunting areas in California by 5-year periods from 1950–87.

Sacramento Valley—About 28% of the average annual visits and 35% of the total harvest on PHAs occurred in the Sacramento Valley where an average of 43% of all ducks wintering in California was located (U.S. Fish and Wildlife Service 1978). Gray Lodge WA was the major harvest site, accounting for 37% of the regional total. Hunter visits and total harvest increased abruptly to peak during 1965–69 (Figure 6), largely due to the addition of Delevan and Sacramento NWRs to the hunting program (Table 1). Harvest declined after 1965–69 and hunter visits declined gradually after a peak in the early 1970s. Hunter success peaked in 1955–59, as in most other regions, but declined with no consistent trend after 1960. Mallards and northern pintails were the primary species in the hunter's bag but the harvest is best described as a "mixed bag" (Figure 7).

Suisun Marsh—Grizzly Island and Joice Island WAs (combined beginning in 1983) were the only PHAs in this region. The region accounted for about 9% of the total annual harvest and 9% of the hunter visits. Hunter visits gradually increased until 1970–74, then declined (Figure 6). Total harvest reflected hunter success more than in other regions. Hunter success peaked during 1955–59, as in other regions, but declined steeply after 1965–69. Related to the decline in hunting success was the decline in the northern pintail harvest (Figure 7). A long-term decline of this magnitude did not occur in other species or regions. Mallards, relatively unimportant until the 1980s, and green-winged teal increased in the bag as pintails declined. Diving ducks were relatively important in this region compared to other regions, peaking at 15% of the harvest during 1980–84.

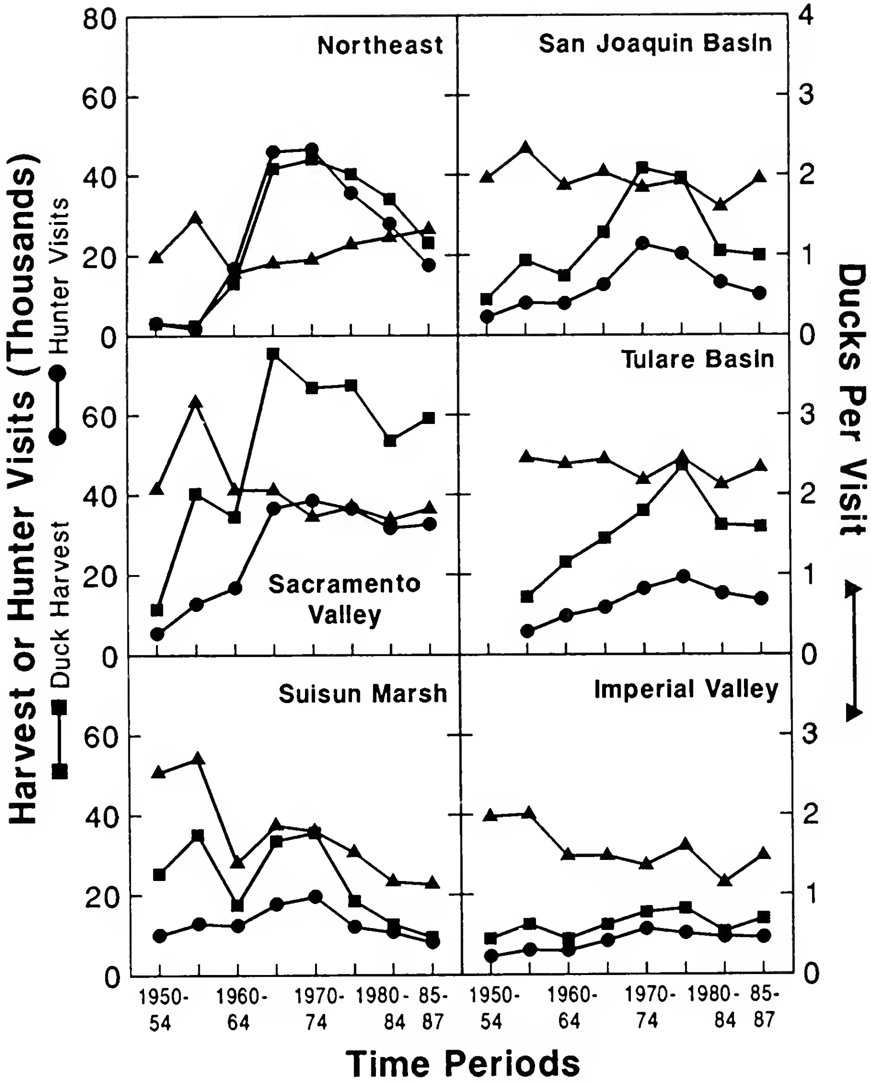


FIGURE 6. Average annual hunter visits, ducks harvested and hunter success (ducks per visit) on public hunting areas in six geographic regions of California by 5-year periods from 1950–87.

San Joaquin Basin—About 17% of the duck harvest and 14% of the hunter visits on PHAs occurred in this region. Volta WA, Los Banos WA, and San Luis NWR each accounted for nearly a third of the regional harvest. Hunter visits and total harvest followed patterns similar to those in other regions (Figure 6). Hunter success peaked during 1955–59 as in other regions, but declined, with no apparent trend, after 1960.Green-winged teal remained the dominant duck in the hunter's bag for over 25 years, while mallards increased as northern pintails declined (Figure 7).

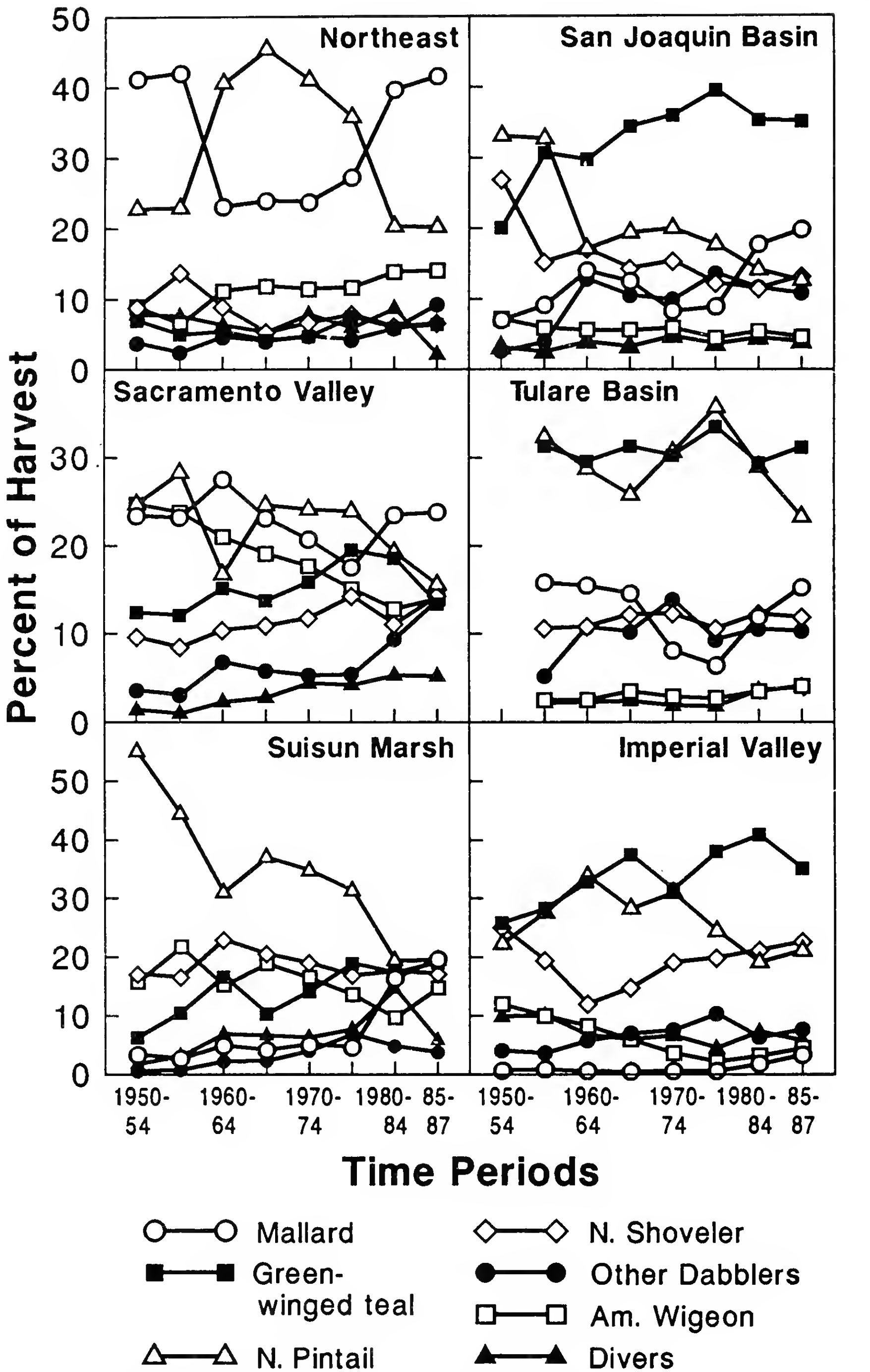


FIGURE 7. Average species composition of the duck harvest on public hunting areas in six geographic regions of California by 5-year periods from 1950–87.

Tulare Basin—This region accounted for 14% of the total visits and 10% of the total duck harvest on PHAs. About 90% of the harvest was from the Mendota WA. The addition of the Kern NWR hunting area in 1973 probably caused hunter visits and harvest to peak later (1975–79) than in other regions (Figure 6). Hunter success was steady and high relative to other regions. Northern pintails and green-winged teal consistently shared primary importance in the harvest (Figure 7).

Imperial Valley—About 8% each of hunter visits and harvest on PHAs occurred in this region. Imperial WA accounted for 90% of the regional harvest. Hunter visits and total harvest each increased concurrent with a decline in hunting success (Figure 6). As in other southern regions, green-winged teal dominated the harvest but northern shovelers steadily increased in the harvest as northern pintails declined (Figure 7).

DISCUSSION

PHA Harvest

Hunter Visits and Harvest Magnitude—Duck harvest on PHAs increased from the 1950s to a peak in the early 1970s as hunters were attracted to newly added PHAs. Harvest reflected hunter visits except for 1960–64 (Figure 4), when decreased numbers of wintering ducks (Figure 1) and more restrictive hunting regulations (Figure 3) may have reduced success and total harvest. Harvest reflected wintering duck population trends except for 1965–69 when increased hunter visits (largely due to the addition of harvest data from Sacramento, Delevan, Tule Lake and Lower Klamath NWRs during this period; Table 1) markedly increased total harvest on PHAs even though duck numbers were down slightly. The relative importance of duck numbers vs. hunting regulations in controlling hunter visits could not be determined because duck regulations have generally changed in concert with duck numbers and the addition of new hunting areas further complicated analysis of hunter visit trends.

PHA harvest and hunter visits declined after the 1970s. Factors contributing to these declines probably include declining hunter opportunity, declining waterfowl populations, increasing complexity of regulations, competing recreational activities, changing hunter population demographics, and increasing costs (Pacific Flyway Study Committee 1988). California hunters may also be influenced by concerns about contaminants in ducks. For example, concerns about the pesticide endrin greatly discouraged waterfowl hunting in Montana in 1981 (J. Bartonek, pers. comm.).

Hunter Success—Changing waterfowl and hunter populations affected hunter success. Success generally reflected midwinter duck numbers 1950–69. However, average success did not increase during 1970–79 despite higher duck numbers and more liberal hunting regulations, nor did it decrease during 1980–87 despite lower duck numbers and more restrictive regulations. The peak in hunter success during the 1950s in most regions probably occurred because hunter interference was low and duck numbers were relatively high. During 1970–79, mutual interference among the numerous hunters, many of whom were probably inexperienced, may have limited hunter success despite abundant ducks and liberal regulations. During recent years (1980–87) the fewer hunters, most of whom were experienced, probably interfered less with

each other (total hunter capacity exceeded hunter visits annually 1978–87 by up to 43%). Thus, hunter success did not decline despite fewer ducks and lower limits. Modern duck hunters are better equipped, more skillful, and more willing to spend money on their sport than were their predecessors (see Miller 1986). The former are probably able to harvest ducks under conditions which previously would have resulted in lower hunter success.

Hunter success trends differed among regions. In contrast to other regions, success on PHAs in the Northeast has increased since the 1960s. We speculate this resulted from establishment of hunter quotas and reduced hunting hours imposed at Klamath Basin NWRs in the 1970s and from increased numbers of over-wintering ducks (J. Hainline, pers. comm.). In recent years, restrictive goose hunting regulations may have caused Klamath Basin hunters to shift their attention to ducks, thereby increasing duck hunting success (E. H. McCollum, pers. comm.).

The decline in hunter success was most evident in regions where northern pintails predominated in the harvest (e.g. Suisun Marsh). Success was more stable in the regions with more varied harvest (e.g. Sacramento Valley).

Harvest Composition—Changes over time in the species composition of the harvest closely reflected changes in the relative abundance of these species in the populations being hunted. For instance, as recently as January 1980 biologists recorded over 3.7 million northern pintails in California during midwinter surveys; in 1987 they recorded only 572,000 (Pacific Flyway Study Committee 1951–84, U.S. Fish and Wildlife Service unpubl. data). The decline in the northern pintail harvest in all regions of California reflected these trends.

Waterfowl managers generally attribute the decline of northern pintails in California since the 1970s to chronic drought on key northerly nesting grounds (Pacific Flyway Study Committee 1987). Conversely, midwinter counts of mallards in California did not decline as precipitously as those of northern pintails and the relative importance of mallards in the harvest increased. Recent analyses indicate that between 51.1% (Trost 1986) and 57.7% (Munro and Kimball 1982) of California's mallard harvest is derived from birds produced within the state. The increased proportion of mallards in the harvest became most obvious during the wet years in California in the 1980s when excellent habitat may have contributed to an increase in local populations. The recent increase in "other dabbler" harvest, (mostly gadwalls), was probably caused by recent increases in the numbers of gadwalls wintering in California (Pacific Flyway Study Committee 1951–84, U.S. Fish and Wildlife Service unpubl. data).

Hunter preference also affected harvest composition. For instance, the importance of mallards and green-winged teal in the harvest generally increased when northern pintails declined. However, during years of relatively high mallard abundance (e.g. 1980–87), the importance of green-winged teal in the harvest declined even though their relative abundance increased (Pacific Flyway Study Committee 1951–84, U.S. Fish and Wildlife Service unpubl. data). These trends suggest that green-winged teal and mallards were increasingly harvested as northern pintails became less available, but mallards were preferred over green-winged teal.

The relative vulnerability of each species to hunting also affected harvest composition. Compared to their relative abundance (proportion of midwinter total duck count), northern pintails were under-represented in the harvest on

PHAs whereas green-winged teal were over-represented. The tendency of northern pintails to gather in large flocks may make hunting them relatively difficult, especially on PHAs where hunter interference can be severe. High vulnerability of green-winged teal to hunting (Bellrose 1944) may have caused this species to be harvested disproportionately relative to their abundance. However, the small size and dispersed nature of green-winged teal may have caused their winter populations to be underestimated.

Overall, the northern shovelers have been important and consistent ducks in the harvest on PHAs. The relatively high proportion of northern shovelers killed by waterfowlers on Imperial Valley PHAs, in spite of their low desirability (Bellrose 1976), may be because of the species' availability and vulnerability (see Van Den Akker and Wilson 1951) and the limited abundance of more desirable species.

Species distribution also affected harvest composition. More mallards have been overwintering in the Northeast, particularly the Klamath Basin NWRs, since the 1970s (J. Hainline, pers. comm.). In this region longer exposure to hunting may have increased their harvest relative to northern pintail. Green-winged teal were harvested most heavily in the three southern regions. Their southern distribution in winter (Bellrose 1976) and their vulnerability (Bellrose 1944) may explain the high incidence of green-winged teal in the harvest there. The proportion of American wigeon gradually declined in the Sacramento Valley (where they were a primary species in the 1950s) and Imperial Valley harvests. Declines in the wintering population and reduced availability of grasslands for foraging (U.S. Fish and Wildlife Service 1978) may explain their reduced importance in the Sacramento Valley harvest. Harvest of American wigeon increased in the Northeast so possibly more were wintering there. A possible but unverified shift to wintering areas in Mexico by American wigeon formerly wintering in the Imperial Valley (suggested by Rienecker 1976) may be responsible for their decline in the southern harvest.

Amount of rainfall in winter appeared to affect the harvest of diving ducks. Heavy rainfall created major open water habitats such as flooded bypasses (see Gilmer et al. 1982) and croplands in the Central Valley, attracting some diver species inland from their normal wintering habitats in San Francisco Bay and coastal areas. Major increases in the kill of divers occurred during the wet period of 1980–84. The proportion of divers harvested in the Suisun Marsh nearly doubled (to 15%) during that period.

PHAs vs. Entire State

Harvest Magnitude, Hunter Visits and Success—Harvest on PHAs comprised a small portion of the total state harvest. During 1961–87, an average of about 190,000 ducks was harvested annually on PHAs compared to estimates for the entire state of 1.6 million determined by the USFWS waterfowl parts survey (J. Bartonek, pers. comm.) and 2.4 million determined by the CDFG mail questionnaire (California Department of Fish and Game, unpubl. data).

Trends in annual harvest for the entire state and for PHAs were generally similar, except that PHA harvest as a proportion of total state harvest increased steadily as estimated by the CDFG mail questionnaire (1950s, 3%; 1960s, 6%; 1970s, 8%; 1980s, 10%; California Department of Fish and Game, unpubl. data)

and the USFWS waterfowl parts survey (1960s, 11%; 1970s, 12%; 1980s, 16%; J. Bartonek, pers. comm.). Addition of new PHAs and the associated increase in hunter visits probably accounted for much of the rise in relative importance of harvest on PHAs during 1950–70. However, after that period no major PHA was added and hunter visits to PHAs as a proportion of total California hunter days (J. Bartonek pers. comm.) increased only slightly (1960s, 11%; 1970s, 12%; 1980s, 13%). Thus, after 1970 the increased importance of harvest on PHAs was probably because hunter success on public areas did not decline as on other areas. Although annual fluctuations in hunter success were similar for PHAs and the entire state (J. Bartonek, pers. comm.), and annual success on PHAs during 1961–70 averaged lower than statewide estimates (mean difference = −26%, range = −34% to −12%), this difference diminished after 1970 (mean difference = 0%, range = −18% to +14%). During the last 4 years of the study, hunter success on PHAs averaged 9% (3% to 14%) greater than state estimates. We speculate that during the recent years of low duck numbers a higher proportion of wintering ducks occurred on NWRs and WAs. Thus, hunting success and hunter visits (to a smaller degree) on private areas apparently declined.

Species Composition—The species composition of harvest on PHAs 1961–87 was similar to estimates for the state (J. Bartonek, pers. comm.), except that preferred species (e.g. northern pintails and mallards) composed a slightly lower proportion of the bag on PHAs than did more vulnerable species (e.g. green-winged teal and northern shovelers). The largest differences were for northern pintails (26.5% vs. 31.5%), green-winged teal (21.0% vs. 17.1%), and northern shovelers (12.5% vs. 8.8%) for PHAs vs. the entire state. Differences may have been caused by unknown biases in mail surveys, differences in habitat between public and private hunting areas, absence of public hunting opportunities in certain key locations (e.g. coastal areas, Sacramento-San Joaquin River Delta, "District 10" east of Gray Lodge WA), and increased difficulty in harvesting preferred species on PHAs because of greater hunter interference.

CONCLUSIONS

The public hunting program in California has provided opportunity for thousands of hunters to participate in a quality waterfowl hunting experience. Loss of habitat since the 1950s, particularly in the Central Valley, has made PHAs increasingly important for waterfowling. Decline in wintering northern pintail populations, changes in hunter attitudes, and numerous other factors have influenced harvest on PHAs. Perhaps the most significant aspect of our summary was the steady decline in hunter visits to PHAs during the last 15 years. This trend is reflected throughout the nation (U.S. Fish and Wildlife Service, unpubl. data) and indicates a loss of interest in the sport of waterfowling. The long term outcome of this pattern is unclear but the potential ramifications are worrisome. Waterfowl hunters have been among the staunchest supporters of wetland preservation programs. If this group continues to diminish, these waterfowl conservation programs are likely to suffer. Resource managers must look for new and innovative strategies to maintain California's valuable wetland and waterfowl resources.

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NOTES

MASS STRANDINGS OF JUVENILE SHORTBELLY ROCKFISH AND PACIFIC HAKE ALONG THE COAST OF NORTHERN CALIFORNIA

Carcasses of young-of-the-year (YOY) shortbelly rockfish, *Sebastes jordani*, and Pacific hake, *Merluccius productus*, littered shores of northern California during June 1988. These strandings caused much concern among observers, but there was little understanding of why they occurred (Klineman 1988). Here we discuss our observations on these and other occurrences during recent years, and draw some conclusions.

At the same time that carcasses littered the beaches, we observed large schools of YOY shortbellies, many in poor condition, during underwater surveys (scuba) near shore along the Sonoma and Mendocino coasts. These were unusual occurrences. Although YOY shortbellies have dominated samples taken offshore by midwater trawl (Peter Adams, National Marine Fisheries Service, Tiburon Laboratory, unpubl. data) we have seen them only occasionally during hundreds of hours of observations near shore over the past 10 years.

The YOY shortbelly schools were most dense right up against rocky shores, where many filled the water from surface to bottom. Virtually every member of these shortline schools was marked by lacerations and/or abrasions, and moribund individuals were common. There were many dead YOY shortbellies on the bottom beneath the schools, and among them lay numerous dead hake. The hake, too, were lacerated and abraded, and, while no living individuals were seen (we have never seen living hake in this habitat), it was clear they had been feeding on the YOY shortbellies. The abdomens of most were greatly distended, and stomachs gorged with YOY shortbellies protruded from the partially decomposed bodies of some (Figure 1).

Probably it is normal that hake prey heavily on YOY shortbellies at this time of year, as do salmon and other coastal predators (Merkel 1957, Lenarz 1980, Chess et al. 1988). We assume that these encounters usually occur offshore above the continental shelf and slope, since that is where hake ordinarily feed (Alverson and Larkins 1969, Gotshall 1969). In fact, hake and YOY shortbellies may be ill-suited to shoreline interactions as predator and prey. Certainly feeding-related behaviors that are adaptive in open water can be maladaptive in confined surroundings. In particular, the explosive, straightforward charge typical of open-water predators, as well as the radiating, evasive response to such attacks typical of schooling prey, are risky maneuvers among rocks or at the water's edge. It is known, for example, that when schools of small fish are driven against the shoreline by large, active predators, subsequent actions often carry both predator and prey onto the beach (Hobson 1968).

The difficulties of maneuvering in confined space would be especially great at night, when visibility is reduced, and we believe that this is when the shortbellies were attacked. Being nocturnal predators (Hart 1973), hake should

function well in dim light. However, their night-feeding normally occurs in obstruction-free surface waters offshore (Alton and Nelson 1970, Livingston 1983), where there is no danger of stranding or of colliding with abrasive surfaces. We suggest that it was the inability of YOY shortbellies and hake to accommodate their behaviors to these dangers in the obstruction-filled waters near shore that resulted in the recently observed mortalities.

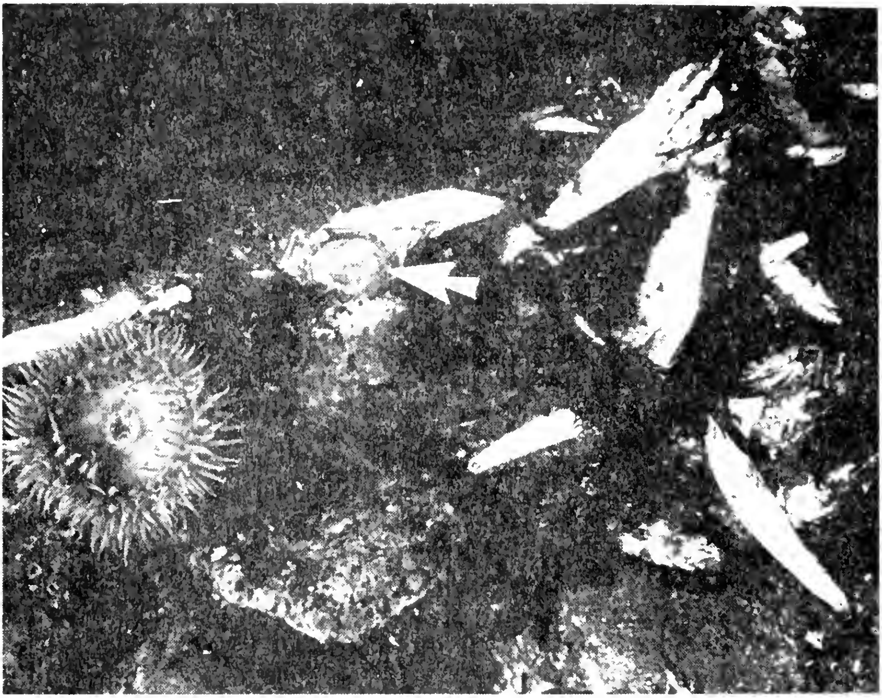

FIGURE 1. Carcasses of hake and shortbelly rockfish on the seabed beneath a shoreline YOY shortbelly school on the Sonoma coast. Arrow points to stomach gorged with YOY shortbellies (readily identifiable through the distended stomach wall) protruding from the decomposed body of a hake.

The acute stress evident in the YOY shortbellies and hake was in sharp contrast with the healthy condition evident in nearby members of the nearshore community. The neighboring residents included YOY of several *Sebastes* species, most notably blue rockfish, *S. mystinus*, black rockfish, *S. melanops*, and yellowtail rockfish, *S. flavidus*. These YOY rockfishes were numerous over most of the nearshore habitat, but, unlike the YOY shortbellies, they were not concentrated at the shoreline. Furthermore, we saw none that appeared in poor condition, none among the carcasses on shore, and none in the stomachs of hake. In fact, we have no evidence they were in any way stressed, which supports our conclusion that the problems suffered by the YOY shortbellies and hake resulted from being maladapted to nearshore conditions, not from problems suffered by the nearshore environment.

While it may be that the hake entered the nearshore habitat to feed on the YOY shortbellies, this still leaves us to question why the YOY shortbellies were there. That the strandings occurred during June follows from this being a time

of year when YOY shortbellies are particularly abundant off northern California (unpublished data from midwater-trawl surveys, Peter Adams, Tiburon Laboratory). But since these fish usually are some distance offshore, why during early June of 1988 were so many close enough inshore to become stranded?

The answer may involve the wind. The strong northerlies that prevail in this region during spring and summer drive the coastal surface waters seaward (Ekman 1904, Bakun 1973), and this acts to keep the YOY shortbellies offshore. But during the month before the strandings short periods of weaker-than-usual northerlies alternated with short periods of southerlies. And on the days immediately before and during our first observations of YOY shortbellies near shore, the wind was from the south at up to 14 knots (Figure 2). Sea temperatures near shore increased sharply at this time, indicating that the surface flow had turned toward the coast (Hobson and Chess 1988), and we believe that this is what brought the YOY shortbellies to the shore.

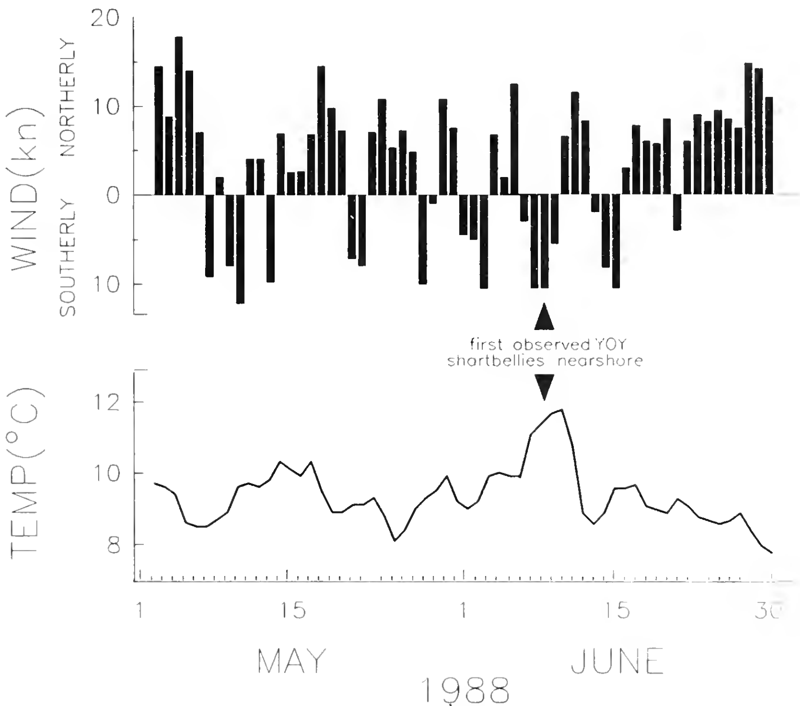

FIGURE 2. Relation between wind and sea temperatures nearshore off the Mendocino coast during May and June, 1988.

Plotted wind values are averages of 2–5 daily readings from the NOAA weather station at Mendocino. Southerly values represent winds from south of east-west axis, northerly values represent winds from north of this axis. *Plotted sea temperatures* are daily means of 72 readings of a digital recording thermometer placed at a depth of 10m in the nearshore habitat.

Previous nearshore occurrences of YOY shortbellies support this hypothesis. Only twice before during the past 10 yr of extensive work in these habitats have we seen large schools of YOY shortbellies close to shore, and both times (early

July 1982 and early June 1985) were similarly marked by southerly winds and abruptly elevated sea temperatures (E. Hobson, Tiburon Laboratory, unpubl. data). We are unaware of strandings during the 1982 episode, but in 1985 we saw YOY shortbellies stranded on the Marin coast, and received reports from fishermen of juvenile shortbellies and hake being stranded along the Mendocino coast. There also were widespread strandings of YOY shortbellies and hake along the Mendocino and Sonoma coasts during late June 1987 (Peter Kalvass, California Department of Fish and Game, pers. comm.), and while we lack wind data for that period (the weather station was closed that week), our thermograph record of sharply elevated sea temperatures indicates that these strandings occurred during an episode of shoreward surface transport. On the other hand, over this same 10-yr period there have been episodes of strong shoreward transport during June–July when no YOY shortbellies were seen near shore, so apparently there are other variables involved.

One of these other variables is likely to be the relative number of YOY shortbellies offshore, and this number differs greatly from year to year with the success of recruitment. Annual assessments of recruitment in this species, based on occurrences of YOY in the gut contents of king salmon, *Oncorhynchus tshawytscha*, have been made since 1980 by Peter Adams and Wayne Samiere, of the Tiburon Laboratory. Significantly, their unpublished results indicate strong recruitment during the four years that YOY shortbellies were noted by us or others to be unusually abundant near shore. Furthermore, their data indicate relatively weak recruitment during the other six years, which may explain why occasional periods of strong shoreward transport during June–July of those years did not, to our knowledge, bring YOY shortbellies near shore.

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NORTHERN RANGE EXTENSION OF THE SPECKLED ROCKFISH, *SEBASTES OVALIS*

The range of speckled rockfish, *Sebastes ovalis*, was previously reported to be from Cape Colnett, Baja California to San Francisco, California (Miller and Lea 1972). One collection and six sightings (Table 1) extend the northern range an estimated 388 nautical miles. One specimen was collected on 15 September 1988 aboard the JEANETTE MARRIE. The 34 cm TL, 583 g male specimen was collected northwest of Cape Blanco, Oregon (lat 43° 01'N., long 124° 51'W) in 148 m using commercial bottom trawl gear. Meristic counts are as follow: dorsal fin XIII,15; anal fin III,8; pectoral fin 18; gill rakers 8+23=31 (both sides). The specimen is preserved in the fish collection at the Department of Fish and Wildlife, Oregon State University, OS 11472.

TABLE 1. Sightings of *Sebastes ovalis* in Oregon Waters.

Date	*Catch Location*	*Latitude*	*Longitude*	*Depth (fms)*	*No. of Fish*	*Capture gear*
8 Aug 79	NW of Cape Blanco	43° 01'N	-	-	1	bottom trawl
17 June 80	W of Heceta Head	44° 12'N	124° 55'W	70	3	midwater trawl
27 April 82	NW of Cape Blanco	42° 58'N	124° 41'W	70	2	bottom trawl
22 March 84	NW of Cape Blanco	43° 02'N	-	78	1	bottom trawl
22 June 84	NW of Cape Blanco	43° 03'N	-	72	1	bottom trawl
5 July 84	W of Heceta Head	44° 01'N	124° 56'W	84	1	midwater trawl

Specimens of *S. ovalis* sighted in Oregon waters were identified by Oregon Department of Fish and Wildlife personnel during routine port sampling and research cruises. The most common species caught in association with *S. ovalis* were yellowtail rockfish, *S. flavidus*, and widow rockfish, *S. entomelas*.

We thank the skippers and crew of the BAY ISLANDER, BERNADETTE, EL MIRAGE, JEANETTE MARRIE, OCEAN BEAUT and QUEEN VICTORIA for their cooperation. This research was supported by Saltonstall-Kennedy Grant no. NA-88-ABH-00017; the NMFS Northwest and Alaska Fisheries Center; the Washington Sea Grant program (Grant no. NA86AA-D-SG044); and the Oregon Department of Fish and Wildlife. Technical paper 8743 of the Oregon State University Agricultural Experimental station.

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RANGE EXTENSIONS OF DECAPOD CRUSTACEANS FROM BAHIA TORTUGAS AND VICINITY, BAJA CALIFORNIA SUR, MEXICO

Decapod crustaceans are the most common invertebrates in the intertidal area of the Baja California (BC) coast. Despite their abundance, some common species are poorly known because their microhabitat, which includes burrows, crevices, and tide pools, has not been carefully examinated. As a result of collections at Bahía Tortugas, Baja California Sur (BCS) (lat 27°39'N, long 114°54'W) and vicinity we obtained new distributional and ecological information for 10 species and subspecies of decapods. A mixture of temperate and warm-water decapods was found. This agrees with Brusca and Wallerstein (1979), who conclude that Bahía Tortugas may be considered as the northernmost significant refugium for tropical-subtropical fauna. The material has been included in the invertebrate collection of the Escuela Superior de Ciencias, Universidad Autónoma de Baja California (UABC). Other specimens were examined from the collection of Crustacea, Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE). Additional records, provided to us by Dr. John S. Garth, are based on material from the Allan Hancock Foundation (AHF), University of Southern California, Los Angeles, from collections made primarily by the "VELERO IV", "SEACHER", and the "Kenyon-Williams" expedition.

Family Porcellanidae

Petrolisthes rathbunae Schmitt, 1921

Previous recorded range.—Monterey Bay to Laguna Beach, California; Santa Barbara Island, California; Isla Guadalupe, Baja California (Haig 1960).

Material examined.—One male, one female, Bahía Tortugas, BCS, 14 April 1987, E. and A.R. Campos, colls., UABC.

Remarks.—This is the first record of this porcellanid crab for the Baja California penninsula. It was collected on sandy-mud and gravel beneath stones, middle intertidal.

Family Grapsidae

Hemigrapsus oregonensis (Dana, 1851)

Previous recorded range.—Resurrection Bay, Alaska, to Bahía Todos Santos, Baja California (Garth and Abbott 1980).

Material examined.—One ovigerous female, Black Warrior (Guerrero Negro) Lagoon, BC (lat 28°00'N, long 114°08'W), 21 March 1956, J.D. Soule and W.K. Emerson, colls., AHF. Two females, one male, Bahía Tortugas, BCS, January–April 1987, E. and A.R. Campos, colls., UABC. Number and sex not stated, Bahía San Juanico, BCS (lat 26°12'N, long 112°28'W), 8 February 1955, J.W. Knudsen, colls., AHF.

Remarks.—This species is uncommon along the rocky intertidal of Bahía Tortugas.

Family Xanthidae

Cataleptodius occidentalis (Stimpson, 1871)

Previous recorded range.—Gulf of California, to Manzanillo, Colima and Galapagos Islands; West Baja California, North to San Ignacio Lagoon (Garth 1960; Brusca 1980).

Material examined.—Two specimens, Bahía Magdalena, BCS (lat 24°45′N, long 112°00′W), 30 October 1971, "SEACHER" station 285, AHF. Six males, 12 females, northern shore, Bahía San Juanico, 7 February 1955, J.K. Knudsen, coll., AHF. One female, northern Whale Islands, Laguna de San Ignacio, BCS (lat 26°39′N, long 113°15′W), 8 February 1950, C.L. Hubbs, M.N. Johnson and A.A. Allanson, colls., AHF. Two males, Bahía Tortugas, BCS, 14 April 1987, E. and A.R. Campos. colls., UABC.

Remarks.—Because this species has been commonly known as *Leptodius occidentalis* we referred to Guinot (1967), who named the genus *Cataleptodius* and discussed its distinction from *Leptodius sensu stricto.*

Lophopanopeus leucomanus leucomanus (Lockington, 1877)

Previous recorded range.—Carmel, Monterey Co., California, to Rosarito, BC (Menzies 1948).

Material examined.—Three males, two females (one ovigerous), Bahía Todos Santos, BC, 30 April 1980, R. Olson, coll., CICESE. Two males, one female, Isla Cedros, BC (lat 28°05′N, long 115°20′W), 31 December 1986, G. Jimenez-Beede, coll., UABC.

Remarks.—The carapace and pereiopods (thoracic appendages) of our specimens fit the description given by Menzies (1948) for this subspecies. However, we found differences in the gonopods (abdominal appendages), primarily the single medial spine (S-1) (Menzies 1948, Figure 9). According to Menzies the S-1 forms an angle of 45° with the shaft, but in our specimens from Isla Cedros the S-1 extends from the shaft at an acute angle. Specimens from Isla Cedros were collected in an unprotected rocky coast on sandy-gravel bottom.

Lophopanopeus bellus diegensis (Rathbun, 1900)

Previous recorded range.—Monterey Bay to Mission Bay, California; Alaska and Washington (extralimital) (Menzies 1948).

Material examined.—One male, one female, Bahía Todos Santos, BC, 15 February 1980, R. Bonfil, coll., CICESE. Two males, Isla Cedros, BC, "Kenyon-Williams" expedition, 12 May 1946, AHF. One female, Isla Cedros, BC, 14 May 1946, AHF. Six males, four females, 3.5 mi N of Isla Natividad light, BC (lat 27°55′N, long 115°15′W), 19–20 fm, "VELERO-IV" station 1706–49, 16 March 1949, AHF. One male, off Cape Tortolo, BCS (lat 27°37′N, long 114°52′W), 1–4 fm, "VELERO-IV" STATION 1707–49, 6 March 1946, AHF.

Lophopanopeus bellus bellus (Stimpson, 1860)

Previous recorded range.—Resurrection Bay, Alaska to Cayucos, San Luis Obispo Co., California (Menzies 1948).

Material examined.—One female, Bahía Tortugas, BCS, 4 January 1987, E. and A.R. Campos, colls., UABC.

Remarks.—Despite the fact that this subspecies has only been recorded north of Cayucos, our female specimen agrees with the description given by

Menzies (1948). The carpus of the walking legs is not markedly bilobed and the carpus of the chelipeds, although showing a strong degree of rugosity on its dorsal surface, does not have the isolated, elevated and irregular bumps that are characteristics of *L. b. diegensis.*

Family Ocypodidae.

Uca (Leptuca) latimanus (Rathbun, 1983)

Previous recorded range.—Puerto Peñasco, Sonora, to Puerto Bolivar, Ecuador (Crane 1975, Hendrickx 1979, Brusca 1980).

Material examined.—Nine males, three females, Los Bungalos, Bahía Tortugas, BCS (lat 27°41′N, long 114°52′W), April–June 1987, E. and A.R. Campos, colls., UABC.

Remarks.—see below.

Uca (Leptuca) musica musica Rathbun, 1914

Previous recorded range.—San Felipe, BC, to La Paz, BCS, and Guaymas, Sonora, to San Blas, Nayarit; West coast of Baja California, north to Bahía Magdalena (Crane 1975, Hendrickx 1984).

Material examined.—150 males and 80 females, Puertecitos, km 72 road San Felipe-San Luis Gonzaga (lat 30°30′N, long 114°40′W), July–September 1986, E. Campos and G. Lopez, colls., UABC. One male, 13 females , Los Bungalos, Bahía Tortugas, BCS, 10 August 1987, E. and A.R. Campos, colls., UABC.

Remarks.—In Bahía Tortugas, both *U. latimanus* and *U. m. musica* were collected on the shore of a semi-enclosed coastal lake, which is temporarily connected to the sea during spring tides. The habitat here is muddy sandflats.

Family Callianassidae

Callianassa affinis Holmes, 1900

Previous recorded range.—Goleta, Santa Barbara Co., California, to Bahía San Quintín, BC (Haig and Abbott 1980).

Material examined.—Five males and four females, Bahía Tortugas, BCS, January–April 1987, E. and A.R. Campos, colls., UABC. Nine males, eight females, Isla Cedros, 1 January 1987, G. Jimenez-Beede, coll., UABC.

Family Upogebidae.

Upogebia macginitieorum Williams, 1986

Previous recorded range.—Santa Catalina Island, Newport Bay, California, to Tijuana Slough (San Diego), California (Williams 1986).

Material examined.—Six females, Punta Morro, Bahía Todos Santos, BC, February–June, 1985, J.R. Campoy-Favela and E. Campos, colls., UABC. 28 males, 21 females (one ovigerous), and seven juveniles, Bahía Tortugas, BCS, January–April 1987, E. and A.R. Campos, colls., UABC.

Remarks.—The morphology of our specimens is almost identical to that of the holotype described by Williams (1986). The habitat recorded for this species is mud and clay banks (Homziak 1981, Williams 1986). In Baja California this species builds burrows in sandy gravel and sandy-muddy gravel, between and beneath boulders. This habitat is similar to that of *C. affinis,* with which *U. macginitieorum* co-occurs. In Bahía Todos Santos *U. macginitieorum* is parasitized by the bopyrid *Phyllodurus abdominalis* and by an undescribed

species of *Pseudione* in Bahía Tortugas (Campos-González and Campoy-Favela 1988, Campos and Campos, in press).

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GROWTH OF HATCHERY-REARED RED ABALONE AT FITZGERALD MARINE RESERVE: ONE YEAR POST-RELEASE

During the summer of 1986 hatchery-reared red abalone, *Haliotis rufescens,* were seeded at Fitzgerald Marine Reserve (FMR), San Mateo County, California (lat 37°31′N, long 122°30′W). A total of 7400 seed abalone representing three size groups (10, 20, and 45 mm) was released at three subtidal and one intertidal site within the Reserve. Site selection was based on known optimum physical and biological requirements for cryptic abalone. To increase the efficiency and effectiveness of seeding abalone, the seeding module release method was used (Ebert and Ebert 1988). To assess abalone survivorship, mortality, growth, and abalone movement, short-term (about one month) and long-term (about one year) post-release surveys were conducted.

Abalone shell growth at FMR was easily distinguished from the hatchery shell growth by color; a diet response (Olsen 1968). The hatchery-reared abalone exhibited a light greenish shell coloration which is typical for abalones fed a giant kelp, *Macrocystis* spp., diet. Giant kelp is a preferred food provided for cultured abalone larger than 10mm (Ebert and Houk 1984). However, abalone shell growth at FMR exhibited a reddish coloration, more typical of wild red abalone stocks, and indicative of foraging on red algae. Giant kelp was not present within FMR, but fleshy red algae(*Opuntiella californica, Botryoglossum farlowianum, Callophyllis* spp., and *Rhodymenia* spp.) were abundant. The abalone seeded at FMR probably foraged on a mixed algal diet. Leighton (1977), in a study comparing shell growth of young red abalone supplied with various algal diets, found that the best growth resulted from a mixed algal diet.

Information on the growth rate of young, cryptically located, red abalone ($\bar{x} \leq 12$ cm) in the wild is lacking. In hatchery settings juvenile red abalone achieve a mean growth rate of about 1.6–1.8 mm/month during the first year of life (Owen et al. 1984). Tegner and Butler (1985), in a southern California study, reported a maximum growth rate of 40 mm in 8.5 months ($\bar{x} = 4.7$ mm/month) for a red abalone that was 69 mm long when released into the wild.

At FMR I observed a mean monthly red abalone growth rate of 1.76 mm (n = 58), 2.35 mm (n = 45), and 3.12 mm (n = 18) for the 10 mm, 20 mm, and 45 mm abalone size groups, respectively. These growth rates were measured 10–12 months post-release. Three of the 45 mm size group red abalone (range = 40–50 mm), found 10 months after their release, had grown 51, 52, and 54 mm. This growth rate ($\bar{x} = 5.23$ mm/month) apparently represents the fastest documented for red abalone released into the wild (Figure 1). Of the three FMR seed abalone that exhibited an excellent growth rate two were males and the other was a female. Gonad examination revealed that all three of these abalone had fairly bulky, ripe gonads and probably were capable of spawning (Ebert and Houk 1984). These seeded abalone are the first known to mature and develop ripe gonads in the wild. This occurrence is significant because the reproductive potential of seeded abalone represents a vital contribution to population enhancement efforts.

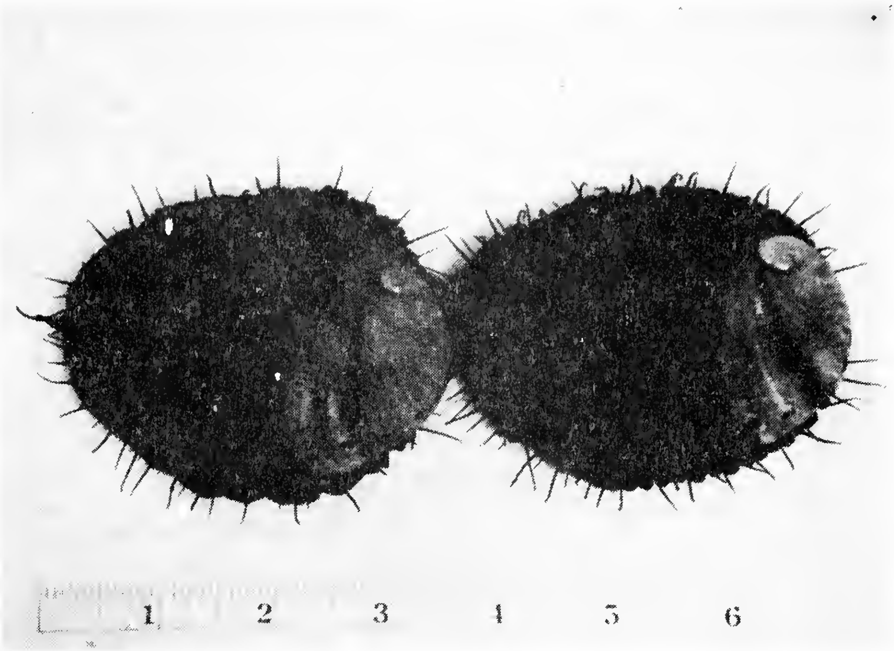

FIGURE 1. Two of the hatchery-reared red abalone seed relocated after 10 months at liberty in Fitzgerald Marine Reserve. They had an average monthly growth rate of 5.15 mm. The lighter colored portion of the shell represents hatchery growth, the darker portion field growth.

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NOTES ON THE FIRST RECORD OF THE ORANGETHROAT PIKEBLENNY, *CHAENOPSIS ALEPIDOTA* (GILBERT), IN MAINLAND CALIFORNIA

On 25 March 1987 Pamela Morris and Laura Targgart, while swimming fish monitoring transects in King Harbor, Redondo Beach, California, recorded the presence of the orangethroat pikeblenny, *Chaenopsis alepidota*, which is the first record from a mainland California location. This blenny occurs as two presumably disjunct populations, one in the Gulf of California, *C. a. alepidota*, and one known from Catalina and Anacapa Islands, *C. a. californiensis* (Böhlke 1957, Stephens 1963). At Catalina Island, *Chaenopsis alepidota* inhabits *Chaetopterus*-like tubes in quiet sand flats. In the 1960's populations were present in many beaches on the leeside of Catalina Island at depths about 10 m. The only record of this fish from Anacapa Island is a photo in California Department of Fish and Game files (Miller and Lea 1972). One explanation for the absence of the species on mainland California is that the protected, clean, shallow sand flat habitat required does not occur there since the coast is regularly encroached upon by winter Pacific storm waves.

The habitat in which the species was first observed at King Harbor is almost the perfect duplicate of the Catalina sand flats. The water depth was 10 m and the area is protected by a rocky breakwater. The sand just inside the harbor entrance is clean, not heavily silted.

We surveyed the King Harbor population on several occasions and about a dozen adults were discovered. The estimated age of older individuals in the population was 3–4 years. Our unpublished data concluded that Catalina specimens of *C. alepidota* reached 60 mm standard length (SL) in one year and grew about 26 mm/yr in subsequent years. The maximum size of aged fish was 133 mm SL (5 years), and the maximum size observed was 153 mm SL, estimated at 6+ years. These data suggest that pikeblennies arrived in King Harbor during El Niño conditions in 1982–83. This 1982–84 El Niño was accompanied by records of a number of a southern tropical species in southern California, including several kyphosids observed in King Harbor (Brooks 1987). Gulf of California and California island populations of *C. alepidota* differ meristically, but these phenotypic differences could easily be induced by temperature differences between the areas. It would appear most likely that the recruitment was from Catalina, but recruitment from the Gulf is possible though unlikely. We did not collect members of the King Harbor population preferring to observe its fate, but a single male found dead beside its tube on 10 August 1988 has the higher counts typical of the California population.

By 10 July 1987, the habitat of the blennies had changed. Large numbers of *Chaetopterus* tubes were uncovered, as though heavy surge had eroded the habitat and the water was quite cold, 11.5°C. Only one animal was discovered in a 30 min search. R. C. Fay (Pacific Biomarine) mentioned that he had seen pikeblennies in the boat channel entrance to King Harbor's Basin 1, an area not included in our surveys. We surveyed that boat channel and found a large number of adult and some young-of-the-year pikeblennies. Further observations are from this site.

On 17 July 1987, we noted breeding behavior and typical male pikeblenny displays (Figure 1) (Thresher 1984). Most displaying pikeblennies occupied tubes located within circular depressions in the sand. The origin of the depressions was revealed when females were observed with displaying males, vibrating their bodies and fins in a circular pattern around the male's tube, displacing sediment from the area. The degree of excavation probably is a good estimate of breeding activity. We were able to observe considerable courtship but observed no females entering male tubes.

FIGURE 1. Courtship display in *Chaenopsis alepidota* (King Harbor, California). Male displays to approaching female, 14 July 1987.

The boat channel habitat is quite unlike other areas where this blenny has been observed in California. It is shallow (3–6 m) and warmed to 22–24°C by Southern California Edison's thermal effluent discharge located about 50 m away. The tubes of the apparently more successful breeding males were on a gentle rise in coarser sand along the deeper edge of a sandy shoal. Elevation may aid the visual effect of the male's display.

Another curiosity was the presence of schooling larvae in the area. Our July 1986 ichthyoplankton samples had recorded pikeblenny larvae in King Harbor prior to our discovery of adult fish. It is now clear that these larvae were probably the first successful spawning of the King Harbor population. Size distributions of established adults suggest several years of successful recruitment. The presence of schools of late presettling and just settled youn-of-the-year in the adult bed at King Harbor suggests that larvae do not regularly disperse, which would explain the maintenance of isolated populations like those at Catalina. If this is the case, the founding of the King Harbor population must have resulted from an unusual event.

On 17 September 1987, we made an approximate count of the boat channel population. More than 50 individuals were observed including many larger older animals and some young-of-the-year. No breeding displays were observed and the excavations around the male tubes had disappeared, though territorial behavior was apparent. Occupied tubes were occasionally less than 1 m apart.

During January 1988, unusually strong winter storms damaged King Harbor. Large waves swept over the breakwater and though the *Chaenopsis* habitats, removing tubes and eroding sand. On 29 January, we made a quick survey of the habitat and observed only one pikeblenny. Pikeblennies prefer *Chaetopterus* tubes with openings flush with the sand. The lone fish we observed was occupying a tube that extended 15 cm above the sand. On 25 February, no pikeblennies were seen. More storms occurred in March and April. By June, the area had stabilized but few *Chaetopterus* tubes remained, and the open sand bottom was heavily littered with debris. During July 1988, we resurveyed both sites formerly occupied by these fish. In the deeper "original" site no tubes or fish were observed. The sand of the shallower boat channel site was almost completely overgrown with a mat of the alga *Enteromorpha*. On 15 July, four adults were found out of tubes (Figure 2) in the algal mat and on 19 July six adults were observed slightly inshore from the previously observed blennies. By 20 July, the algal mat was dying and clear sand areas were developing. On 21 July, we located seven adults, all in tubes. No reproductive or territorial behavior was observed. On 26 August, unusually cold water (12.7°C) was present and six established pikeblennies were observed, a seventh observed dead on the sand was collected.

FIGURE 2. Pikeblenny in tube protruding from *Enteromorpha* mat, 15 July 1988.

Surveys from September 1988 to January 1989 did not find pikeblennies, but following harbor dredging (March–April 1989) six to eight adults appeared at the channel site and have established there.

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—John S. Stephens, Jr., Michael Singer, and Laura Targgart, Vantuna Research Group, Occidental College, Los Angeles, California 90041. *Accepted for publication April 1989.*

BOOK REVIEWS

SEASHORE LIFE OF SOUTHERN CALIFORNIA

By Sam Hinton. 1987 (revised edition). University of California Press, Berkeley, CA, 217 p., illustrated. $10.95 paperback.

When I first began to work in the nearshore areas of California in the early 1970s, the one guide which accompanied me was the original edition of Sam Hinton's guide. It practically never let me down in the early years, but like any guide of this kind, it begins to age with arrival of new information and changes in the scientific names of the organisms.

Now I am pleased to report on a new edition of Sam Hinton's classic guide. Every section has been updated and improved.

The presentation of the taxonomy of the various groups has been improved, and that of the individual animals has been brought up to date. There are now 264 species included, an increase of 27. Many of the color plates have been rephotographed, and their number has also been increased.

The first sections present a thorough discussion of the natural forces which so affect nearshore animals, namely, the tides, winds, storms, currents, surf, and ocean chemistry. This is followed by a section relating the ocean forces to the intertidal habitat. There is also a map of locations in California where the reader might go to see the organisms described in the book.

A particularly important section deals with conservation of nearshore areas, and this concept is repeatedly made throughout the book.

A most useful feature of the book is description of the animal and interesting field notes, identification aids, and a line drawing (sometimes a color plate) provided for the animals. Sam Hinton's knowledge and insight go far to give the reader an appreciation of seashore life and the difficulties encountered by the animals living there.

While today there are a number of other guides with the same coverage as Sam Hinton's guide, they are all considerably more expensive, and one would think twice about taking them into the field. At $10.95, *Seashore Life of Southern California* is a bargain, and is small enough to tuck into a knapsack. This book is a must for anyone interested in learning more about marine life along southern California's shore areas.

—Peter L. Haaker

INSTRUCTIONS TO AUTHORS

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California Fish and Game is a technical, professional, and educational journal devoted to the conservation and understanding of fish and wildlife. Original manuscripts submitted for consideration should deal with the California flora and fauna or provide information of direct interest and benefit to California researchers and managers. Authors should submit the original manuscript plus two copies, including tables and figures.

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3. *Abstracts*—Every article must be introduced by a concise abstract. Indent the abstract at each margin to identify it.

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